Nuytsia

WESTERN AUSTRALIAN HERBARIUM
VOLUME 21 PAGES 1–185 2011

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WESTERN AUSTRALIAN CONSERVATION SCIENCE CENTRE
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The Department of Environment and Conservation's new Western Australian Conservation Science Centre, which incorporates the Western Australian Herbarium (PERTH).

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VOLUME 21 PAGES 1-185 2011

DEPARTMENT OF ENVIRONMENT AND CONSERVATION
WESTERN AUSTRALIA

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CONTENTS

Papers **Page**

Five new species of *Calandrinia* from Western Australia with additional information on morphological observations. F.J. Obbens 1

Wurmbea fluviatilis (Colchicaceae), a new riverine species from the Gascoyne region of Western Australia. T.D. Macfarlane and A.L. Case 25

New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid. B.L. Rye, M.Hislop, K.A. Shepherd and C. Hollister 35

Stackhousia stratfordii (Celastraceae: Stackhousioideae), a remarkable new species from a remote location near Norseman, south-west Western Australia. W.R. Barker and G.T.B. Cockerton 69

New, locally endemic taxa in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from the Perth and midwest regions of Western Australia. M. Hislop 75

Labichea rossii (Fabaceae: Caesalpinioideae), a new species from the Yilgarn Ranges, Western Australia. N. Gibson 91

A new and rare species of *Ptilotus* (Amaranthaceae) from a suburban wetland of the eastern Swan Coastal Plain, Western Australia. R.W. Davis and C. Tauss 97

An assessment of infraspecific taxa in *Ptilotus* (Amaranthaceae) from Western Australia. R.W. Davis 103

A revision of *Dielsiodoxa* (Ericaceae: Styphelioideae:Oligarrheneae). D.E. Albrecht and M. Hislop 107

Sida picklesiana (Malvaceae), a new species from the Murchison-Gascoyne region of Western Australia. A.S. Markey, S. Dillon, G.T.B. Cockerton and R.M. Barker 127

Two species of *Inocybe* (fungi) introduced into Western Australia. N.L. Bougher and P.B. Matheny 139

Eremophila koobabbiensis (Scrophulariaceae), a new, rare species from the wheatbelt of Western Australia. R.J. Chinnock and A.B. Doley 157

A reinstatement and a new combination in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae). M. Hislop 163

Amanita ochroterrea and *Amanita brunneiphylla* (Basidiomycota), one species or two?. E.M. Davison 177

Short Communications

Valid publication of *Ptilotus stirlingii* subsp. *australis* (Amaranthaceae). R.W. Davis and R. Butcher 31

Removal of the informal name *Epiblema grandiflorum* var. *cyaneum* ms from the Census of Western Australian Plants. K.R. Thiele 33

Re-evaluation of some infraspecific taxa in *Ptilotus* (Amaranthaceae). R.W. Davis 149

Validation of the name *Drosera monticola* (Droseraceae), a species from the south-west of Western Australia. A. Lowrie 152

Melaleuca marginata, a new name for *Melaleuca coronicarpa* (Myrtaceae). M. Hislop, B.J. Lepschi and L.A. Craven 153

Other contents

Corrections 155

Referees for Volume 21 185

Five new species of *Calandrinia* (Portulacaceae) from Western Australia with additional information on morphological observations

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Abstract

Obbens, F. J. Five new species of *Calandrinia* (Portulacaceae) from Western Australia with additional information on morphological observations. *Nuytsia* 21(1): 1–23 (2011). Four new Western Australian species in *Calandrinia* section *Pseudodianthoideae* von Poellnitz are described as: *C. flava* Obbens, *C. tholiformis* Obbens, *C. sculpta* Obbens & J.G.West and *C. vernicosa* Obbens. A fifth species of uncertain sectional placement is described as *C. pentavalvis* Obbens. One of the new species is found solely in coastal areas of the South West Botanical Province, one occurs within the Eremaean Botanical Province while the remaining three occur in both these regions. Notes on some field and laboratory observations of the morphology of *Calandrinia* are discussed.

Introduction

One aim of this paper is to describe a number of currently phrase-named species within the genus *Calandrinia* which are endemic to Western Australia. In recent years, the number of phrase-named species has steadily increased due to ongoing taxonomic investigation and extensive fieldwork, and this trend appears likely to continue. Consequently, there is a need for documentation to enable these new species to be readily recognized, in particular by those associated with field surveys related to mining approvals. Four of these species are currently phrase-named on the *Census of Western Australian Plants* while the fifth is a closely related species to one of the four, but has not been phrase-named due to its very recent discovery.

Another aim is to provide information regarding morphological observations of some *Calandrinia* characters which may help improve species recognition especially for field workers. This section also highlights the diversity observed in the genus and helps to address a lack of adequate documentation on the morphology of *Calandrinia*.

Methods

For each of the new species described, measurements were taken from either dried pressed material or from material preserved in 70% ethanol. All spirit specimens were measured wet. Frequent large variations in plant size and in other morphological characters occur within the genus, both within and between populations due to environmental and seasonal conditions. Therefore, measurements are presented as ranges compiled from specimens of several populations across the species distribution and from both dried and spirit materials. Most measurements were made using a microscope graticule. Occasionally an estimate is given where an exact measurement was not possible. Stem, scape and inflorescence axis were measured as per the instructions in the last section. Bracts on the inflorescence axis were measured flattened out, but shape is described for bracts *in situ*. Sepal shape was described and measurements taken *in situ* on flowering specimens. Flowering times for each species are based on specimen details augmented by field observations.

SEM images were produced using a Zeiss 1555 VPSEM microscope. Microscope parameters varied for different images, but the ranges were: current 6-10 Kv, working distance 4–11 mm and aperture 30 μm. Seed specimens were sputter-coated with gold before scanning. Images were subsequently processed using Photoshop 2.0.

Taxonomy

Calandrinia flava Obbens, *sp. nov.*

Calandriniae eremaeae Ewart affinis sed petalis flavis, seminis nitidis leviter colliculatis.

Typus: Private property remnant just to the east of Solomon Road and *ca.* 0.5–1.0 km north of intersection with Bestry Road, 30–35 km directly east-south-east of Morawa townsite, Western Australia, 25 September 2008, *F. Obbens & B. Newman* FO 56/08 (*holo*: PERTH 08139962; *iso*: CANB).

Calandrinia sp. Murchison - Gascoyne (F. Obbens & F. Hort FO 49/04), Western Australian Herbarium, in *Florabase*, http://florabase.dec.wa.gov.au [accessed 24 January 2011].

Annual herb; root system a small taproot with several finer lateral roots. *Plant* semi-erect to erect, occasionally decumbent, 15–145 mm tall, 10–170 mm wide, glabrous. *Basal leaves* fleshy, elliptic to obovate, sometimes oblong, 2.8–25 mm long, 0.7–3.8 mm wide, with a medial shallow groove on the adaxial surface, grey-green to dark purple-brown. *Stems* few to several (usually 1–9), 3–120 mm long, radiating out and slightly upwards from base, occasionally branched. *Stem leaves* fleshy, narrowly elliptic to obovate sometimes broader, to 16 mm long and 4.4 mm wide, alternate, usually in small clusters at stem ends. *Scapes* 3.5–45 mm long and bare. *Inflorescence axis* 7.5–75 mm long, bare except for 3 to several ± scarious bracts opposite each flower pedicel, generally forming a loose cyme. *Inflorescence axis bracts* appressed to ± spreading, triangular, occasionally narrowly so, 0.8–3.0 mm long, 0.5–1.7 mm wide, apex acute to long-acuminate. *Pedicel* 2.5–6.8 mm long, erect, to 12 mm long in fruit, moderately reflexed. *Flowers* 2.9–5.6 mm diameter. *Sepals* thin, ovate to broadly ovate, 1.7–3.0 mm long, 1.4–3.4 mm wide, free to base, prominently 3 to 5 nerved. *Petals* 5, bright yellow occasionally suffused with red, obovate, emarginate and with a small mucro, 2.3–3.0 mm long, 1.5–2.1 mm wide, free to base. *Stamens* 6–12 in 1 row, alternating long and short, occasionally one or two stamens slightly offset from the row; filaments free, 0.7–1.7 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on lower basal adaxial portion; anthers broadly elliptic to broadly oblong in outline, 0.25–0.55 mm long, 0.2–0.5 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* ellipsoid to obovoid, 1.0–1.2 mm diameter, light brown. *Stigmata* 3, ovate to somewhat triangular and incurved, elongating and spreading slightly outwards with maturity, 0.5–1.1 mm long, free to base of ovary, mostly covered with moderately dense and relatively long stigma trichomes. *Capsule* ovoid to broadly ovoid, 1.7–3.8 mm long, 1.4–2.4 mm wide, apex obtuse, usually protruding beyond the sepals; valves 3, splitting from apex to base. *Seeds* 18–52, dark red-brown to black, glossy, reniform to slightly orbicular, 0.45–0.65 mm long, 0.42–0.63 mm wide, the surface is lightly patterned with moderately-sized colliculate structure. (Figures 1, 2A–C).

Other specimens examined. WESTERN AUSTRALIA: 22.3 km S of Wannoo (Billabong Roadhouse) on Highway 1, 11 Aug. 1991, *B.G. Briggs* 8848 *& L.A.S. Johnson* (NSW 243905); River pool, Wooramel River, 500 m downstream of crossing on road to Gilroyd Homestead, 30 Aug. 1995, *G.J. Keighery & N. Gibson* 671 (PERTH 04973585); *c.* 3.2 km E of Coolcalalaya Station homestead on road to Yallalong Station, 16 Sep. 2004, *F. Obbens and F. Hort* FO 49/04 (PERTH 06981291); *c.* 38 km E of Coolcalalaya Station homestead on road to Yallalong Station, 16 Sep. 2004, *F. Obbens & F. Hort* FO 53/04 (PERTH 06981259); claypan to the E of Blue Hills Range, *c.* 65–70 km directly NE of Perenjori, 5 Sep. 2007, *F. Obbens* FO 5/07 (PERTH 07701020); Koolanooka Hills towards the southern end of the main range, *c.* 18 km E of Morawa townsite, 24 Sep. 2008, *F. Obbens & B. Newman* FO55/08 (PERTH 07991452); Burnerbinmah Station, S boundary, Charraminda Paddock, 23 Aug. 1997, *S. Patrick s.n.* (PERTH 05207452); Quadrat East H6 on Eurardy Station, *c.* 43 km N of Kalbarri turnoff on the North West Coastal Highway, 4 Oct. 2003, *Wildflower Society of WA* EURA 59 (PERTH 06861458).

Distribution. Occurs in the south-western parts of the Eremaean Botanical Province and northern parts of the Geraldton sandplains and Avon Wheatbelt districts of Western Australia (Figure 3).

Habitat. Occurs in open shrubland or woodlands in red-brown sandy loams to heavier clay soils on plains, claypans or river edges to moderately steep slopes off small ranges. Some sites are described as having scattered stones or rocks on the surface. The woodlands include *Eucalyptus salmonphloia*, *E. loxophleba*, *E. camaldulensis* and *E. victrix* along arid zone rivers. Shrubland sites are generally dominated by *Acacia* species (e.g. *A. aneura*, *A. tetragonophylla*, *A. acuminata*) and sometimes melaleucas, eremophilas and various species in the families Chenopodiaceae and Asteraceae.

Phenology. Flowers and fruits: September to October.

Conservation status. Probably a fairly common species with a relatively wide distribution, although much of this area is either pastoral or agricultural. There are conservation areas within its range where it is likely to occur.

Etymology. From the Latin *flavus* (yellow) referring to the colour of the petals.

Notes. This species is usually a small to medium-sized plant superficially similar to *Calandrinia eremaea* Ewart in habit, flower size and shape and capsule morphology. It could easily be mistaken for that species when not in flower or if the seeds have been shed. It differs in having glossy, lightly patterned seeds while *C. eremaea* has seeds that are strongly patterned, finely colliculate, have a metallic lustre and are frequently papillate. *Calandrinia flava* seeds are somewhat similar to those of *C. liniflora* Fenzl, *C. calyptrata* Hook.f. and *C. remota* J.M.Black in being glossy, but seeds of *C. flava* are lightly patterned with a moderately-sized colliculate structure whereas the others are normally smooth (i.e. not patterned). *Calandrinia flava* has yellow petals sometimes suffused with red while those of *C. eremaea* are generally pink. A collection from East Yuna Nature Reserve (*G.J. Keighery & B.J. Keighery* 536: PERTH 07288352) is described as pink-flowered. Close examination of the specimen shows the flower buds and old flowers to be a yellowish colour like many other collections of this species and the seeds match those of *C. flava*. The label description is possibly in error and requires field confirmation.

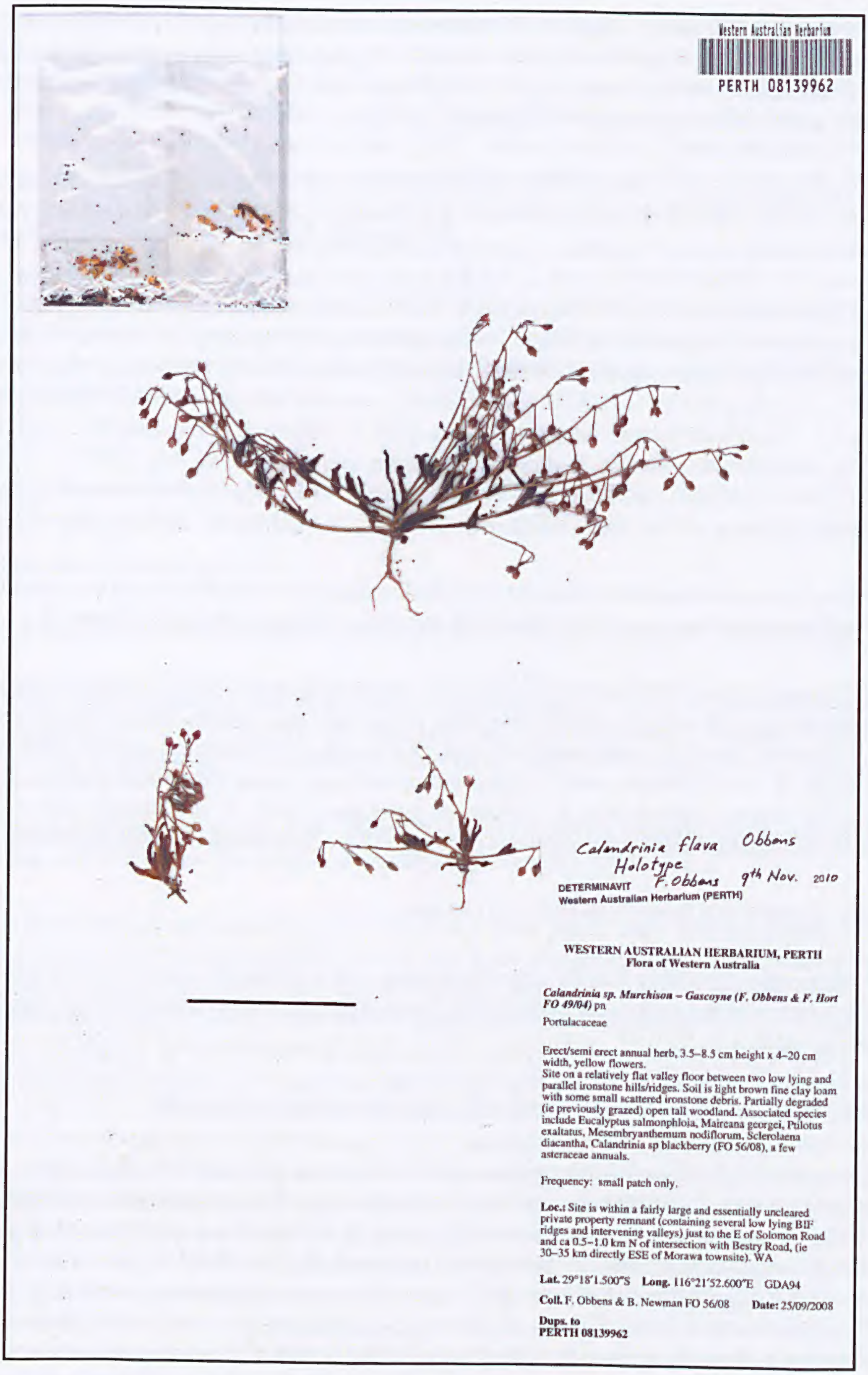

Western Australian Herbarium
PERTH 08139962
Calandrinia flava Obbens
Holotype
F. Obbens 9th Nov. 2010
DETERMINAVIT
Western Australian Herbarium (PERTH)
WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia
Calandrinia sp. Murchison – Gascoyne (F. Obbens & F. Hort FO 49/04) pn
Portulacaceae
Erect/semi erect annual herb, 3.5–8.5 cm height x 4–20 cm width, yellow flowers.
Site on a relatively flat valley floor between two low lying and parallel ironstone hills/ridges. Soil is light brown fine clay loam with some small scattered ironstone debris. Partially degraded (ie previously grazed) open tall woodland. Associated species include Eucalyptus salmonphloia, Maireana georgei, Ptilotus exaltatus, Mesembryanthemum nodiflorum, Sclerolaena diacantha, Calandrinia sp blackberry (FO 56/08), a few asteraceae annuals.
Frequency: small patch only.
Loc.: Site is within a fairly large and essentially uncleared private property remnant (containing several low lying BIF ridges and intervening valleys) just to the E of Solomon Road and ca 0.5–1.0 km N of intersection with Bestry Road, (ie 30–35 km directly ESE of Morawa townsite). WA
Lat. 29°18'1.500"S Long. 116°21'52.600"E GDA94
Coll. F. Obbens & B. Newman FO 56/08 Date: 25/09/2008
Dups. to
PERTH 08139962

Figure 1. Holotype of *Calandrinia flava* (*F. Obbens & B. Newman* FO 56/08; PERTH 08139962). Scale bar = 5 cm.

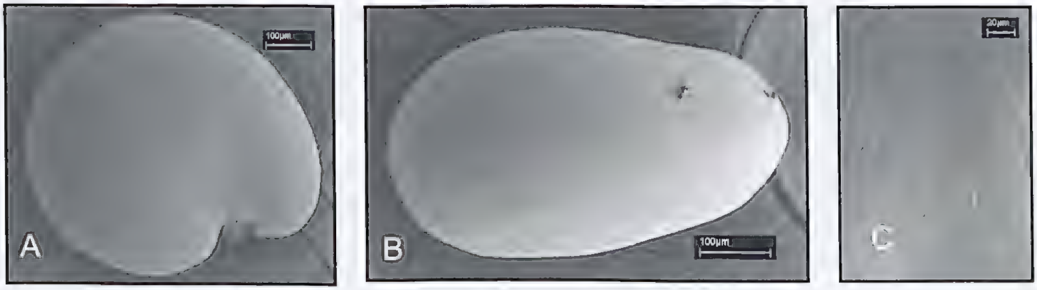


Figure 2. SEM of *Calandrinia flava* seed. A – plan view; B. – dorsal view; C – surface pattern at higher magnification.

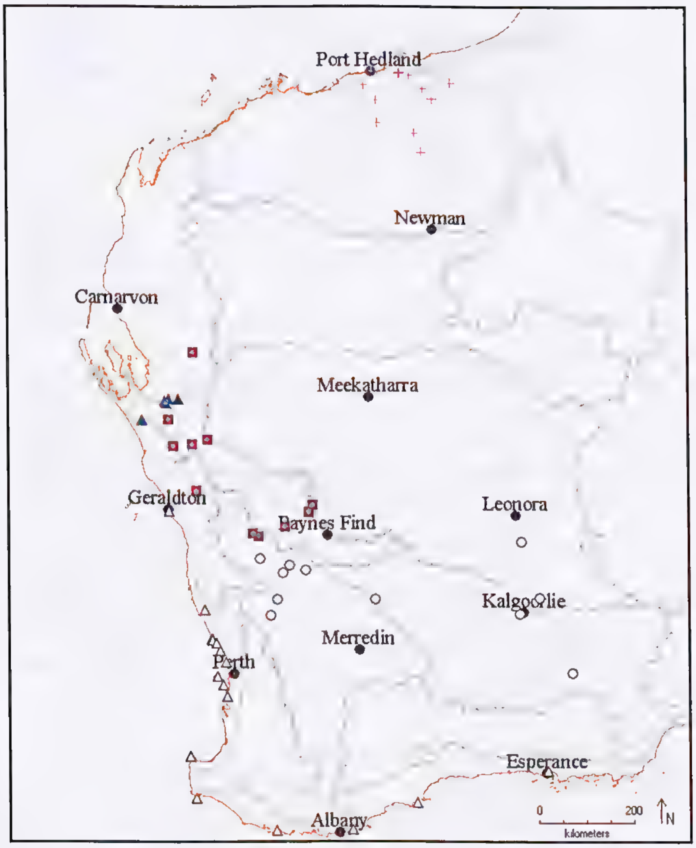


Figure 3. Distributions for *Calandrinia flava* (■), *C.tholiformis* (Δ), *C. pentavalvis* (+), *C. sculpta* (○) and *C. vernicosa* (▲).

Calandrinia tholiformis Obbens, *sp. nov.*

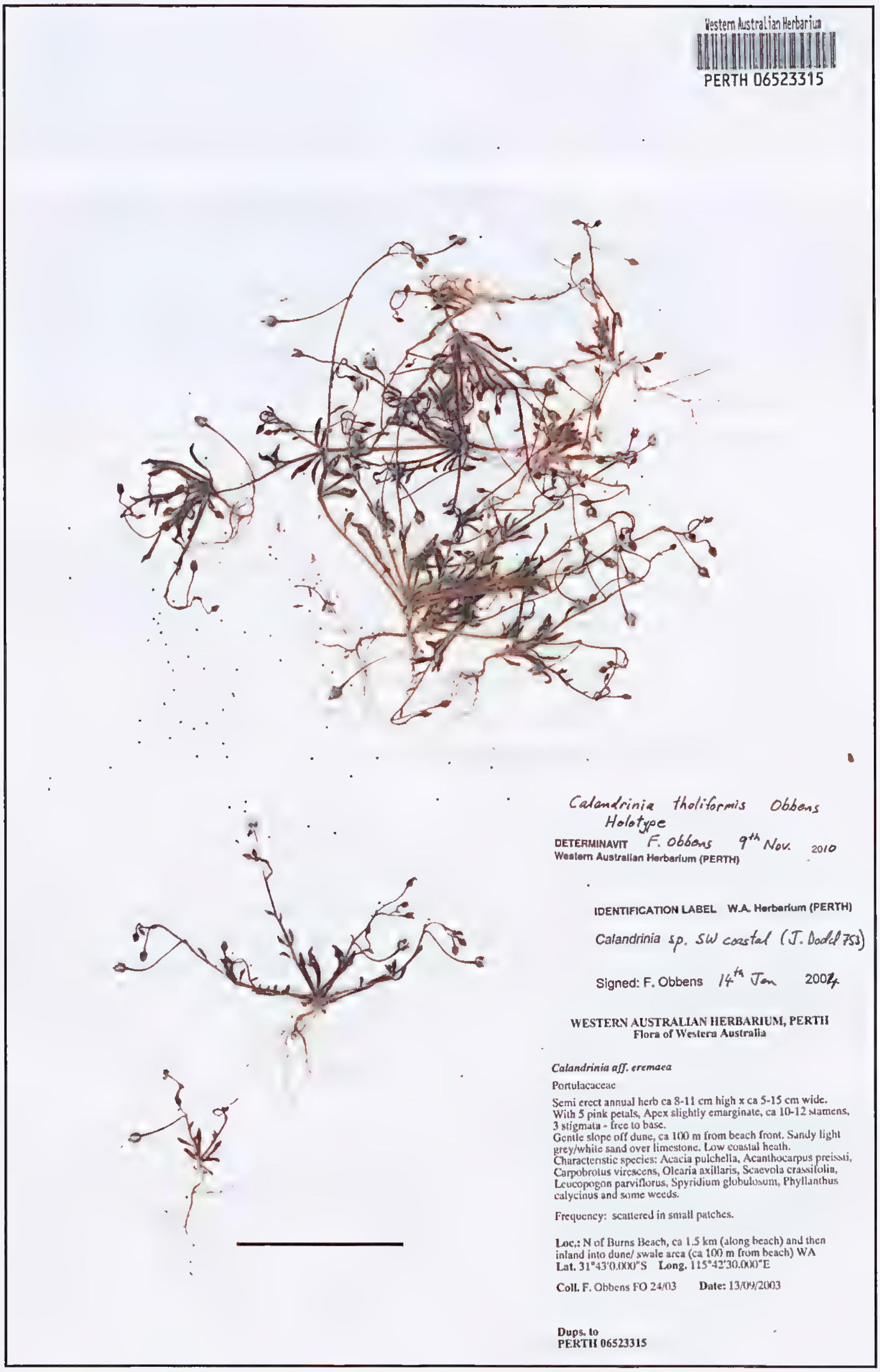
Calandriniae eremaeae Ewart affinis sed seminis aliquantum grandioribus, colliculis alte tholiformibus differt.

Typus: *c.* 1.5 km north along Burns Beach, in dune/swale area off beach, Western Australia, 13 September 2003, *F. Obbens* FO 24/03 (*holo*: PERTH 06523315; *iso*: CANB, MEL).

Calandrinia sp. SW Coastal (J. Dodd 753), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed 24 January 2011].

Annual herb; root system a small taproot with several finer lateral roots. *Plant* semi-erect to erect, occasionally decumbent, 30–150 mm tall, 30–200 mm wide, glabrous. *Basal leaves* fleshy, obovate to spathulate, 2.8–37 mm long, 0.7–7.8 mm wide, with a medial shallow groove on the adaxial surface, green to yellow-green. *Stems* few to several (usually 2–9), 5–75 mm long, radiating out and slightly upwards from the base, sometimes with a short erect central stem forming an axis for a few lateral stems. *Stem leaves* fleshy, narrowly obovate to narrowly spathulate, sometimes elliptic, frequently with a small mucro at apex, to 24 mm long and 4.3 mm wide, alternate, usually in small clusters at stem ends. *Scapes* 7–66 mm long, bare except for 1–3 reduced leaves near base. *Inflorescence axis* 5–60 mm long, bare except for 2 to several ± scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts* ± spreading, narrowly triangular to triangular, 1.3–3.7 mm long, 0.4–2.0 mm wide, the apex acuminate. *Pedicel* 4.8–15 mm long, erect, to 28 mm long in fruit, moderately to strongly reflexed. *Flowers* 4.6–8.2 mm diameter. *Sepals* thin, ovate to broadly ovate, 2.2–4.1 mm long, 2.2–4.4 mm wide, free to base, usually 3–5 nerved. *Petals* 5, light to mid pink, rarely white, narrowly obovate to obovate, occasionally broader, with a distinct notch at the apex, 3.1–4.6 mm long, 1.6–2.8 mm wide, very shortly connate at base for 0.3–0.5 mm. *Stamens* 9–20 in 1 row (or ?2 rows), alternating long and short, with each alternate stamen (or at least a third of the stamens) very slightly offset laterally to the next (not always clearly seen); filaments free, 0.7–2.3 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on adaxial side at base; anthers elliptic to oblong in outline, 0.4–0.6 mm long, 0.4–0.5 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 1.1–1.3 mm diameter, brown. *Stigmata* 3, narrowly triangular to linear, spreading with maturity, 0.7–1.1 mm long, free to base of ovary, covered with sparse to moderately dense long stigma trichomes. *Capsule* ovoid to broadly ovoid, 2.5–3.7 mm long, 1.7–2.9 mm wide, apex obtuse, usually equal to or slightly exceeding sepals; valves 3, splitting from apex to base. *Seeds* 13–61, dark red-brown to black, ± shiny, reniform to orbicular with a relatively large strophiole, 0.5–0.65 mm long, 0.5–0.63 mm wide, surface pattern of broad, high domes on the sides and smaller domes on the dorsal area, with no boundaries evident around each dome (i.e. no 'cellular' structure). For some variants the domes on the seed's side faces are closer and elongated producing a normal colliculate pattern (i.e. with cellular boundaries) locally. (Figures 4, 5A–H).

Other specimens examined. WESTERN AUSTRALIA: Hilltop E of Quokka Information, near entrance to Kingstown, Rottnest Island, 18 Sep. 1999, *J. Dodd* 753 (PERTH 05565979); *c.* 5 km SSE of Geraldton and *c.* 3 km directly E from the coast, 26 Sep. 2007, *C. Godden* SLU113-5 (PERTH 07578008); Seabird, vacant crown land, 14 Sep. 1995, *G.J. Keighery* 14099 (PERTH 04582535); Port Kennedy Scientific Park, 19 Oct. 2001, *F. Littleton* 68 (PERTH 06019714); Ridgeway Drive, Short Beach, Bremer Bay, 2 Oct. 2004, *K. Macey* 685 (PERTH 06943187); *c.* 1.5 km N of Skippy Rock Road on Cape to Cape Track, Cape Leeuwin area, 27 Sep. 2003, *F. Obbens* FO 51/03 (PERTH 06550789); on walk trail *c.* 0.33 km directly NE of Cape Naturaliste Lighthouse, 27 Sep. 2003, *F. Obbens* FO 52/03 (PERTH 06550770); between Moates Lake and Gardner Lake just S of Juniperina Creek, Two Peoples Bay



Western Australian Herbarium
PERTH 06523315

Calandrinia tholiformis Obbens
Holotype
DETERMINAVIT F. Obbens 9th Nov. 2010
Western Australian Herbarium (PERTH)

IDENTIFICATION LABEL W.A. Herbarium (PERTH)
Calandrinia sp. SW coastal (J. Dodd 753)
Signed: F. Obbens 14th Jan 2004

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Calandrinia aff. eremaea

Portulacaceae

Semi erect annual herb ca 8-11 cm high x ca 5-15 cm wide. With 5 pink petals, Apex slightly emarginate, ca 10-12 stamens, 3 stigmata - free to base.
Gentle slope off dune, ca 100 m from beach front. Sandy light grey/white sand over limestone. Low coastal heath.
Characteristic species: Acacia pulchella, Acanthocarpus preissii, Carpobrotus virescens, Olearia axillaris, Scaevola crassifolia, Leucopogon parviflorus, Spyridium globulosum, Phyllanthus calycinus and some weeds.

Frequency: scattered in small patches.

Loc.: N of Burns Beach, ca 1.5 km (along beach) and then inland into dune/ swale area (ca 100 m from beach) WA
Lat. 31°43'0.000"S **Long.** 115°42'30.000"E

Coll. F. Obbens FO 24/03 **Date:** 13/09/2003

Dups. to
PERTH 06523315

Figure 4. Holotype of *Calandrinia tholiformis* (F. Obbens FO 24/03 – PERTH 06523315). Scale bar = 5 cm.

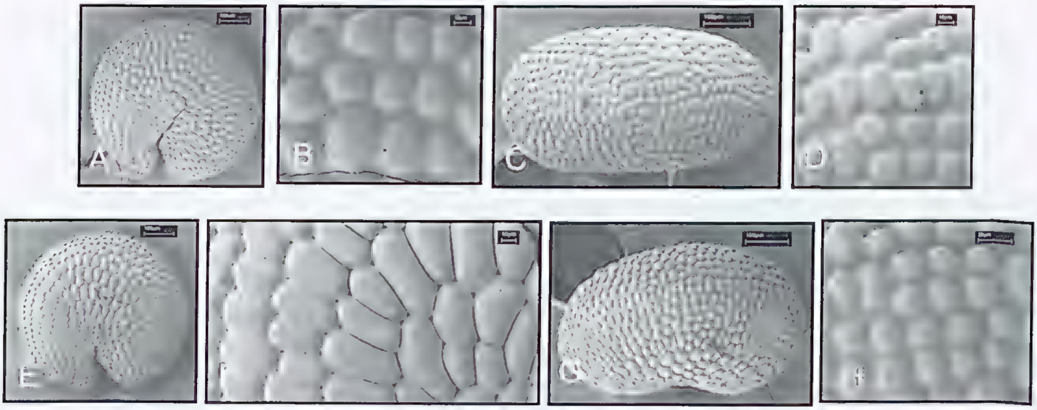


Figure 5. SEM of *Calandrinia tholiformis* seeds. A–D. Variant 1. A – plan view whole seed; B – plan view higher magnification; C – dorsal view whole seed; D – dorsal view higher magnification; E–H. Variant 2. E – plan view whole seed; F – plan view higher magnification; G – dorsal view whole seed; H – dorsal view higher magnification.

Nature Reserve, 21 Oct. 1975, *G.T. Smith & L.A. Moore s.n.* (PERTH 05319412); domestic property, Frank Freeman Drive, Esperance, 4 Sep. 2005, *C.D. Turley* 1/905 (PERTH 07409281); Tiwest mineral sand lease (Mullering survey project), Cataby area, 20 Oct. 2005, *G. Woodman & K. Rodda* M74-4 (PERTH 07215576).

Distribution. Located in coastal areas and nearby islands within the South West Botanical Province from just south of Geraldton to Esperance (Figure 3).

Habitat. Calandrinia tholiformis occurs in a number of coastal or near coastal habitats including the lower slopes of large dunes, smaller dunes, within swale areas, in shallow soils over limestone ridges and near coastal lake systems. It is generally found within 100 m and up to 3 km from the coast, rarely occupying the immediate foreshore areas. Soils are usually grey, grey-brown to yellow-brown sandy loams. It occurs in a variety of vegetation types including low coastal heath, grass/sedge flats, low open woodland and open areas between tall shrubland. Frequently associated species include *Acanthocarpus preissii*, *Acacia rostellifera*, *A. lasiocarpa*, *Conostylis candicans*, *Guichenotia ledifolia*, *Lomandra maritima*, *Lepidosperma gladiatum*, *Melaleuca huegelii*, *M. systena*, *Scaevola crassifolia* and *Spyridium globulosum*.

Phenology. Flowers: September and October.

Conservation status. This taxon is quite common. Currently there are 16 collections in PERTH from localities between Geraldton and Esperance. The greatest threat to its conservation is future urban expansion having localized impacts. There are significant coastal areas under conservation title in the region where it exists.

Etymology. From the Latin *tholus* (dome) and *formis* (shape) referring to the dome-shaped protrusions on the seed surface of this species.

Notes. Calandrinia tholiformis may be related to *C. eremaea* because of their superficial similarities in habit, flower size and flower structure. It differs in having slightly larger seeds with a surface pattern of high, broad domes while *C. eremaea* seeds are colliculate with a metallic lustre and are often papillate. The *C. tholiformis* seed surface pattern described above is somewhat variable, typically displaying no 'cellular' structure in between the high, globular domes (Figure 5B). In some variants the domes are closely packed and elongated on the seed's side faces producing a somewhat normal colliculate pattern (Figure 5F).

Several other species occur along the south west coastal zone including *C. brevipedata* F.Muell., *C. calyptrata*, *C. corrigioloides* Benth., *C. granulifera* Benth., *C. liniflora* and *C. polypetala* Fenzl. Most of these prefer different habitats, infrequently co-occur, rarely are found on the foreshore areas (i.e. within 0.5–1.0 km of the beachfront, apart from *C. brevipedata*) and in the main are relatively easy to distinguish from each other. A recent addition to this list is *Calandrinia*. sp. Two Rocks (K. Richardson 211). *Calandrinia* sp. Two Rocks (K. Richardson 211) is a much larger, erect plant than *C. tholiformis* and has significantly larger flowers, many more stamens and larger seeds. It appears to prefer the immediate foreshore and dune habitats generally less than several hundred metres from the beach front. Both species co-occur at some sites (e.g. Port Kennedy Scientific Park, near Rockingham, Western Australia).

There are three problematic collections, all with seeds that appear almost identical to *C.* sp. Two Rocks (K. Richardson 211), but whose smaller habit, smaller flowers and collection locations are more akin to *C. tholiformis*. All three collections are currently undetermined and include PERTH 07811152 from Grey Point, Peel Harvey Inlet; PERTH 07215584 from the Mullering area of Tiwest mining lease, Cataby and PERTH 07771207 from a track south of Wongonderrah Rd, Cataby. These three collections are either hybrids or possibly represent one or more unnamed taxa. The Grey Point specimen, in particular, probably represents the latter option.

Calandrinia pentavalvis Obbens, *sp. nov.*

Species planta erecta petalis 9–12 et capsula 5-valvi a congeneribus diversa.

Typus: *ca.* 7 km east of the Shaw River along the Marble Bar-Hillside Road, then follow minor track north for *ca.* 400 m. Area referred to as the Spear Hills, and is *ca.* 60 km SW at Marble Bar, Western Australia, 28 May 2004, *F. Obbens & B. Bromilow* FO 16/04 (*holo*: PERTH 06609570).

Calandrinia sp. Pinga (T.R. Lally TRL 722), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed 24 January 2011].

Annual herb; root system a taproot with several lateral roots. *Plant* semi-erect to erect, rarely prostrate and sometimes scrambling, 70–520 mm tall, 80–1000 mm wide, glabrous. *Basal leaves* fleshy, narrowly linear to narrowly oblanceolate tapering to an acute apex, 6.0–83 mm long, 0.5–3.3 mm wide, subterete, dull green to green-brown. *Stems* few to several (usually 1–6), 30–175 mm long, radiating out and upwards from base, occasionally branched low near base. *Stem leaves* fleshy, narrowly linear to narrowly oblanceolate, often with a small mucro at apex, to 66 mm long and 2.8 mm wide, alternate, occasionally with leaf clusters at stem ends. *Scapes* 15–85 mm long, bare. *Inflorescence axis* 35–460 mm long, bare except for several or more ± scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts* ± appressed, narrowly triangular to triangular, 2.5–6.6 mm long, 1.1–5.0 mm wide, apex acuminate, occasionally long-acuminate with recurved apices. *Pedicel* 8.0–49.5 mm long, erect, to 85 mm long in fruit, moderately to strongly reflexed. *Flowers* 17–30 mm diameter, usually with a long calyptra after flowering is complete. *Sepals* thin, ovate to broadly ovate, 4.6–9.1 mm long, 4.5–9.8 mm wide, free to base, with midvein and some reticulation obvious and a hyaline edge. *Petals* 9–12, bright mid-pink, sometimes lighter, narrowly obovate to obovate, with a distinct, small mucro at apex, 7.7–16.5 mm long, 2.4–5.2 mm wide, free to base, occasionally shortly connate at base. *Stamens* 64–121 in three ill-defined rows; filaments free, 1.5–5.5 mm long, attached to the top of a basal ring beneath the ovary, minutely papillose on lower half of filament on adaxial side; anthers elliptic to oblong in outline, 0.9–1.6 mm long, 0.5–0.8 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 1.8–2.4 mm diameter, cream to light brown. *Stigmata* (4) 5 (6), narrowly triangular, spreading somewhat at maturity, 1.8–3.3 mm long, on a short style 0.15–0.6 mm long, sparsely covered with moderately long stigma trichomes. *Capsule* ovoid, occasionally broadly ovoid, 5.2–8.4 mm long, 3.8–5.7 mm wide, apex obtuse, normally equal to or slightly exceeding sepals; valves (4)5(6), initially splitting to one third then from apex to base with age. *Seeds* 43–107, dark red-brown to black, dull, subreniform, 0.8–1.0 mm long, 0.52–0.9 mm wide, 0.45–0.65 mm thick; surface of radially swirled ridges, each ridge topped with a row of papilla-like spheres and with colliculate pattern continuing perpendicular to and between the ridges. (Figures 6, 7A–C).

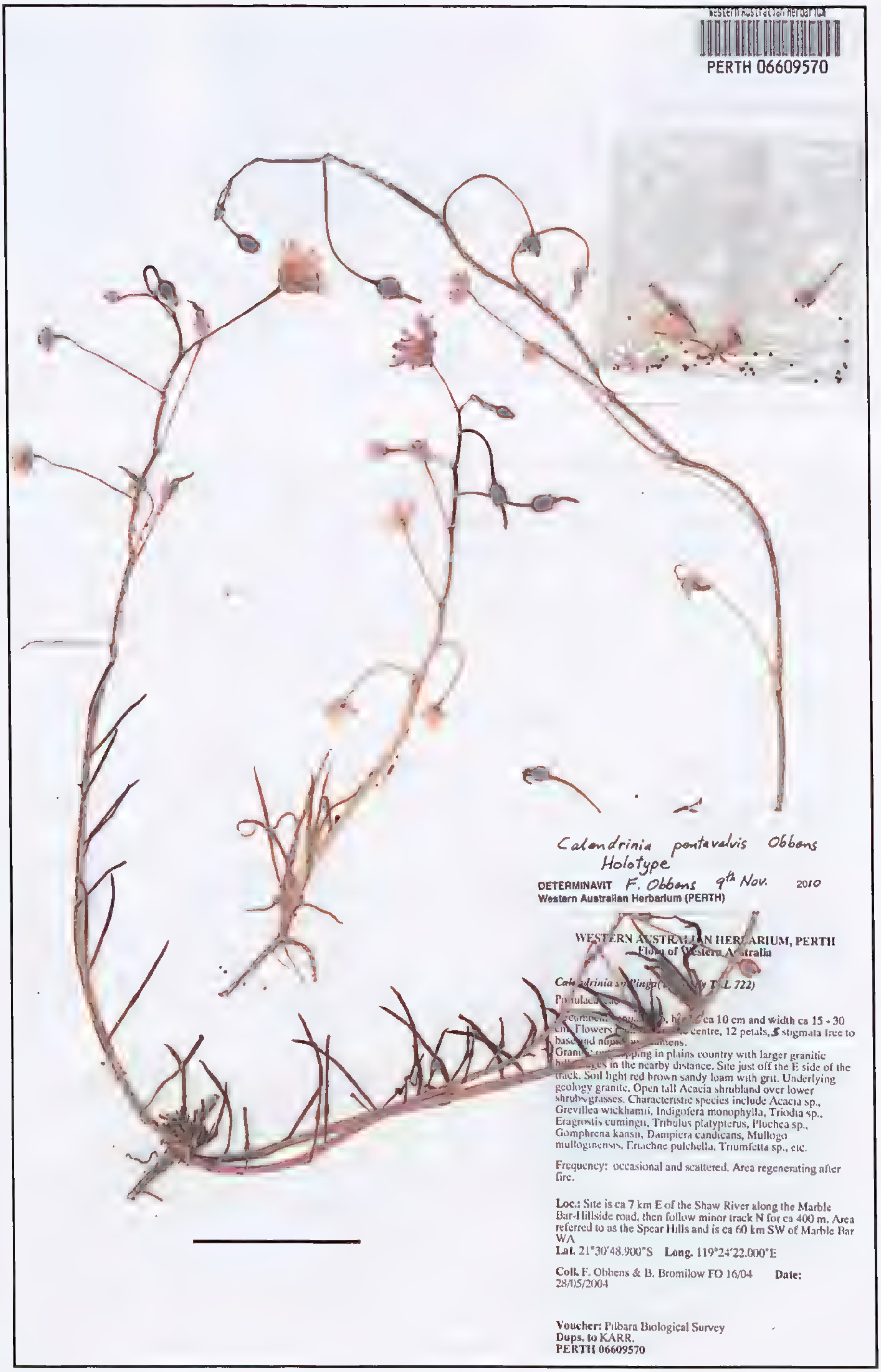
Other specimens examined. WESTERN AUSTRALIA: FMG Cloudbreak Mine-Pilbara, 15 May 2006, *J. Atkinson s.n.* (PERTH 07887337); Oyster Inlet, near Hedland [i.e. Port], 30 September 1981, *G. Craig* 318 (PERTH 06491944); 19.1 km N of Pinga Creek, *c.* 130 km by road S of Port Hedland towards Wittenoom Gorge to Roy Hill Road, 9 Sept 1995, *T.R. Lally* TRL 722 (PERTH 04355342); C235, Coongan station, Pilbara Region, 23 June 1997, *A.A. Mitchell* PRP 1567 (PERTH 05100933); 13 km SW of Shay Gap (town), 16 July 1984, *K. Newbey* 10569 (PERTH 07423322); Beside Great Northern Highway *c.* 54 km E of Port Hedland turnoff and several kilometers before Strelley River bridge, 25 May 2004, *F. Obbens & B. Bromilow* FO 7/04 (PERTH 06609465); *c.* 21 km S along the Great Northern Highway from Wodgina mine access road turnoff (i.e. *c.* 100–110 km directly S of Port Hedland), then site is *c.* 200 m E of Highway, 29 May 2004, *F. Obbens & B. Bromilow* FO 20/04 (PERTH 06609619); Site I745, 1 km W of Warralong Community, Coongan Station, E Pilbara, 23 Aug 1997, *S.M.E. Van Vreeswyk* PRP 1871 (PERTH 05908191).

Distribution. Wholly distributed in the Pilbara Region of the Eremaean Botanical Province within roughly a 100 to 150 km radius of Port Hedland (Figure 3).

Habitat. Collected from a fairly wide variety of situations including flats, alluvial plains, near estuarine inlet, undulating country, sandplain adjacent to claypan and drainage lines. Soils at collecting sites are red-brown, sandy or clayey, often gritty-loams with one collection from orange quartzy loam, frequently in association with granitic geology at the surface. *Calandrinia pentavalvis* usually occurs in grassland often dominated by *Triodia* spp. (e.g. *T. wiseana*, *T. pungens*, *T. brizoides*) with some sparse, taller, emergent shrubs such as *Grevillea wickhamii*, *Indigofera monophylla*, *Acacia pyriformis* and *Tribulus platypterus*. The species is often a weak, scrambling plant using grass tussocks and smaller shrubs for support, but has also been observed as being quite capable of self support. It is also known to occur in very open *Acacia* shrubland (dominated by e.g. *A. ancistrocarpa*, *A. orthocarpa*, *A. stellariceps*). The understorey at many of these sites includes grasses, *Pluchea tetranthera*, *Gomphrena kansii*, *Dampiera candicans*, *Polycarpaea corymbosa* etc.

Phenology. Collections in flower range from late May to early September, however, the actual flowering period each year is probably shorter with a start and finish dependent on seasonal conditions.

Conservation status. There are currently eleven collections of *Calandrinia pentavalvis* at PERTH distributed over a wide area. It appears to be quite common although much of its range is either pastoral or mining lease.



Calandrinia pentavalvis Obbens
Holotype
DETERMINAVIT F. Obbens 9th Nov. 2010
Western Australian Herbarium (PERTH)

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Calandrinia [illegible] (T.L 722)

Po[illegible]

[illegible] ca 10 cm and width ca 15 - 30 cm. Flowers [illegible] centre, 12 petals, 5 stigmata free to base and [illegible] stamens.
Granite [illegible]pping in plains country with larger granitic [illegible] in the nearby distance. Site just off the E side of the track. Soil light red brown sandy loam with grit. Underlying geology granite. Open tall Acacia shrubland over lower shrubs grasses. Characteristic species include Acacia sp., Grevillea wickhamii, Indigofera monophylla, Triodia sp., Eragrostis cumingii, Tribulus platypterus, Pluchea sp., Gomphrena kansii, Dampiera candicans, Mollugo molluginensis, Eriachne pulchella, Triumfetta sp., etc.

Frequency: occasional and scattered. Area regenerating after fire.

Loc.: Site is ca 7 km E of the Shaw River along the Marble Bar-Hillside road, then follow minor track N for ca 400 m. Area referred to as the Spear Hills and is ca 60 km SW of Marble Bar WA
Lat. 21°30'48.900"S **Long.** 119°24'22.000"E

Coll. F. Obbens & B. Bromilow FO 16/04 **Date:** 28/05/2004

Voucher: Pilbara Biological Survey
Dups. to KARR.
PERTH 06609570

Figure 6. Holotype of *Calandrinia pentavalvis* (*F. Obbens & B. Bromilow* FO 16/04; PERTH 06609570). Scale bar = 5 cm.

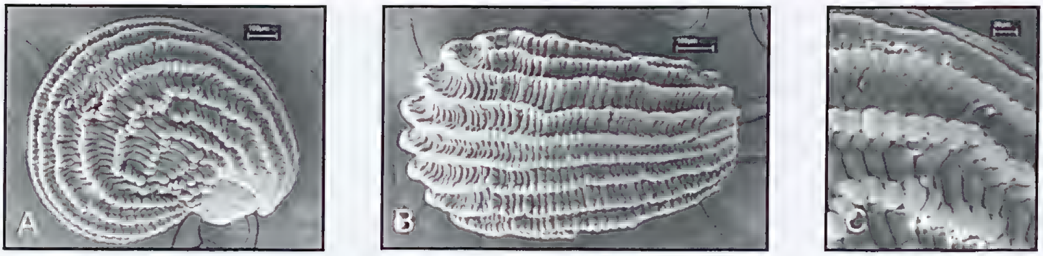


Figure 7. SEM of *Calandrinia pentavalvis* seed. A – plan view; B. – dorsal view; C – edge view at high magnification.

Etymology. From the Latin *penta* (five) and *valvis* (valved), in reference to the normally five-valved capsules found in this taxon.

Notes. *Calandrinia pentavalvis* is a relatively large, mostly an erect plant with quite large flowers and nine to twelve bright pink petals. Only *C. strophiolata* (F.Muell.) Ewart, B.Rees & B.Wood and *C.* sp. Mt Clere (R.J. Dadd 5) are larger-flowered plants with similar petal numbers to *C. pentavalvis*, but these two species appear unrelated in all other respects. The affinities of *C. pentavalvis* are uncertain, and it is unusual in the genus because of its normally five-valved capsules. The currently recognized sections within *Calandrinia* are based on whether species have three-valved or four-valved capsules or are tuberous. Future molecular studies may help to resolve the relationships of *C. pentavalvis*.

Calandrinia sculpta Obbens & J.G.West, *sp. nov.*

Flore *C. polyandro* Benth. affinis sed seminis aliquantum grandioribus et aliter colliculosis differt.

Typus: *ca.* 45.8 km north of Wubin townsite, Western Australia, on Great Northern Highway, north-west side of highway and at edge of saltpan/samphire area, 13 October 2003, *F. Obbens* FO 64/03 (*holo*: PERTH 06708196 (sheet 1), PERTH 06708218 (sheet 2); *iso*: CANB, MEL).

Calandrinia sp. ridged papillate (M. Hislop & E. Hudson MH161), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed 24 January 2011].

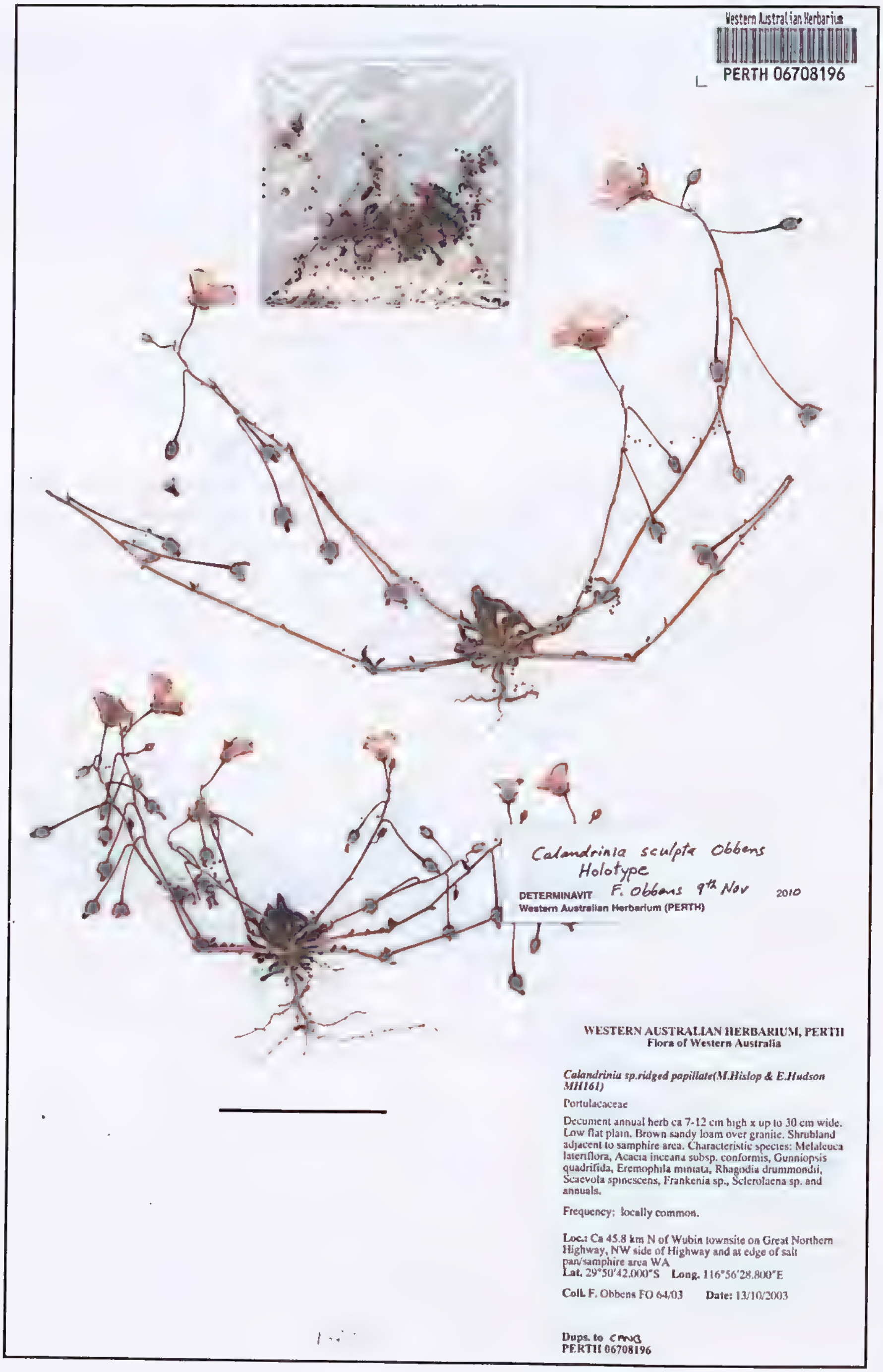
Annual herb; root system a small to moderately-sized taproot with several lateral and finer roots. *Plant* decumbent, semi-erect or erect, 42–170 mm tall, 25–350 mm wide, glabrous. *Basal leaves* fleshy, narrowly obovate to narrowly spathulate, sharply tapering to apex with small distinct mucro, 7.5–38 mm long, 1.0–7.7 mm wide, with a distinct shallow medial groove on adaxial surface, green to greenish red-brown or greenish grey-brown. *Stems* few to several (usually 1–9), 10–190 mm long, radiating out and upwards from base, rarely once-branched. *Stem leaves* fleshy, narrowly elliptic to obovate, occasionally broadly obovate, to 16 mm long and 5.5 mm wide, alternate, with leaf clusters at stem ends. *Scapes* 15–155 mm long, bare. *Inflorescence axis* 15–85 mm long, bare except for a few to several ± scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts* ± spreading, narrowly triangular to triangular, 1.2–4.2 mm long, 0.6–3.0 mm wide, apex long-acuminate. *Pedicel* 8.5–31.5 mm long, erect, to 37 mm in fruit, moderately reflexed. *Flowers* 9–27 mm diameter. *Sepals* ± thin, ovate to broadly ovate, 3.0–6.5 mm long, 3.6–8.8 mm wide, free to base, with 3 or 5 prominent veins and some reticulation. *Petals* 5, mid-pink to purple, broadly obovate to very broadly obovate, sometimes narrower, slightly undulate towards the apex with a shallow notch at mid-apex, 7.5–13.6 mm long, 5.7–12 mm wide, free to base. *Stamens* 44–90 in three ill-defined rows; filaments free, 0.9–4.1 mm long, attached to the top of a basal ring beneath the ovary, moderate to strongly papillose on lower fifth of filament on adaxial side; anthers elliptic to oblong in outline, occasionally ovate in outline, 0.6–1.0 mm long, 0.4–0.6 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, occasionally broadly so, 0.8–2.1 mm diameter, brown, with 3 obvious, shallow valve abscission lines. *Stigmata* 3, broadly triangular becoming narrowly triangular and spreading with maturity, 1.8–3.3 mm long, densely covered with moderately long stigma trichomes, free to base. *Capsule* ovoid, occasionally broadly ovoid, 2.9–5.7 mm long, 2.6–4.7 mm wide, the apex obtuse, normally equal to or slightly shorter than the sepals; valves 3, splitting from apex to base with age. *Seeds* 35–71, dark red-brown to black, occasionally metallic, shiny particularly on large papilla facets, subreniform, 0.75–1.0 mm long, 0.55–0.85 mm wide, 0.5–0.65 mm thick; surface of several, prominent dorsal ridges formed by rows of large irregular papillae with the most outer ridges formed by elongate and raised cells that protrude to the side and with colliculate pattern elsewhere on the side faces. (Figures 8, 9A–C)

Other specimens examined. WESTERN AUSTRALIA: 5 miles from Kalgoorlie on Coolgardie Road, 18 Aug. 1947, *N.T. Burbidge* 1898 (PERTH 07692811); 1 km S of Niagara Dam [i.e. Menzies/Leonora area], 4 Sep. 1985, *B.J. Conn* 1950 (NSW 199959); Geranium Rock *c.* 60 km NE of Kalannie, 3 Sep. 1995, *M. Hislop & E. Hudson* MH161 (PERTH 04864883); decomposed granite breakaways, *c.* 800 m WNW of granite peak of Geeraning Rock, NE of Mukinbudin, 16 Oct 2005, *M. Hislop & F. Hort* MH3533C (PERTH 07421435); saline pan 8 km S of Bunjil, 8.5 km WNW of intersection of Coorow-Latham Road and Mullewa-Wubin Road, SAP wetland site SPS 172B, 3 Oct. 2000, *M.N. Lyons & S.D. Lyons* 3993 (PERTH 07867735); Camp Rock, 20 Sep. 1980, K.R. Newbey 7493 (PERTH 06144276); on Piawaning - Wongan Hills Road where it crosses the Mortlock River North flats, small rise on S verge nearly opposite intersection with Smith Road, 12 Oct. 2003, *F. Obbens* FO 57/03 (PERTH 06708080 – sheet 1 & PERTH 06708099 – sheet 2); *c.* 11.2 km N of Ballidu townsite on W side of main road to Dalwallinu and just S of saline pan, 12 Oct. 2003, *F. Obbens* FO 59/03 (PERTH 06708110); *c.* 22.4 km N of Wubin townsite on Great Northern Highway, junction with old rabbit proof fence track, NW side of highway, 13 Oct. 2003, *F. Obbens* FO 61/03 (PERTH 06708153); 22 km NE Kanowna, 14 Oct 1992, *L. Sweedman* S2264 (KPBG).

Distribution. The distribution of *Calandrinia sculpta* covers a wide band running diagonally from the Paynes Find and Wongan Hills areas to the south-east around Leonora and Norseman stradding the border of the South West and Eremaean Botanical Provinces (Figure 3).

Habitat. Calandrinia sculpta has been collected most frequently from areas adjacent to saline flats or saline pans; however, it also has been collected from decomposed granitic breakaways and from around granite rocks. In these locations the soils range from brown, sandy loams to grey-brown, silty sand-loam to orange-brown sands. One site was described as red-brown clayey loam. The range of vegetation types is diverse including open tall shrubland of *Melaleuca lateriflora, M. stereophloia, Acacia inceana, Eremophila oldfieldii* and *E. miniata* etc. Other vegetation types include dwarf shrubs over herbs, thicket over low shrubs and shrub or heath communities where these intergrade with samphire. Common to many of these sites are chenopod species in the genera *Atriplex, Maireana, Rhagodia* and *Tecticornia,* sometimes with *Frankenia* species and salt-tolerant Asteraceae species.

Phenology. Flowers between late August and early November with the peak period during September and October. The considerable range of distribution somewhat accounts for the long apparent flowering period plus responses to yearly seasonal conditions.



Calandrinia sculpta Obbens
Holotype
DETERMINAVIT F. Obbens 9th Nov 2010
Western Australian Herbarium (PERTH)

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Calandrinia sp.ridged papillate(M.Hislop & E.Hudson MH161)

Portulacaceae

Decument annual herb ca 7-12 cm high x up to 30 cm wide. Low flat plain. Brown sandy loam over granite. Shrubland adjacent to samphire area. Characteristic species: Melaleuca lateriflora, Acacia inceana subsp. conformis, Gunniopsis quadrifida, Eremophila miniata, Rhagodia drummondii, Scaevola spinescens, Frankenia sp., Sclerolaena sp. and annuals.

Frequency: locally common.

Loc.: Ca 45.8 km N of Wubin townsite on Great Northern Highway, NW side of Highway and at edge of salt pan/samphire area WA
Lat. 29°50'42.000"S Long. 116°56'28.800"E

Coll. F. Obbens FO 64/03 Date: 13/10/2003

Dups. to CANB
PERTH 06708196

Figure 8. Part of the holotype of *Calandrinia sculpta* (*F. Obbens* FO 64/03; PERTH 06708196). Scale bar = 5 cm.

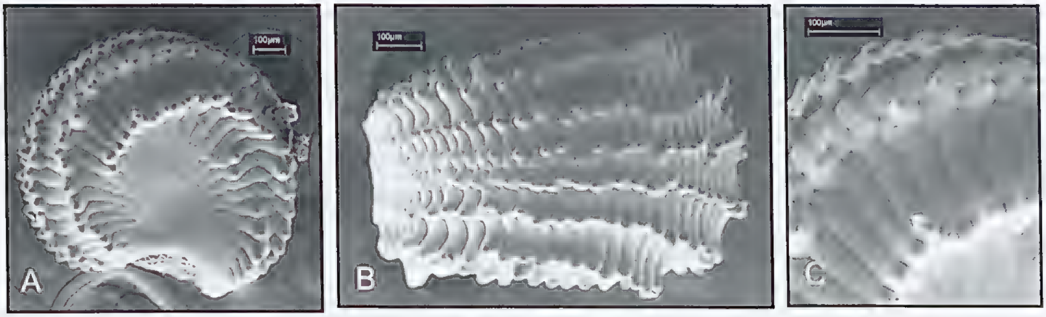


Figure 9. SEM of *Calandrinia sculpta* seed. A – plan view; B – dorsal view; C – edge view at high magnification. Scale bar on each image.

Conservation status. There are currently 15 collections of *Calandrinia sculpta* at PERTH distributed over a very wide area. Mining, pastoral and agricultural activities occur throughout its range. It probably occurs in a number of large conservation reserves throughout this area.

Etymology. From the Latin *sculptus*, referring to the highly sculptured effect of the patterned seeds.

Notes. The affinities of *Calandrinia sculpta* are uncertain. There are a small number of other five-petalled species with mid-pink and mid-sized flowers within the range of *C. sculpta* which are commonly mistaken for and have a superficial likeness to, *C. polyandra* Benth. These species include *C. remota*, *C. sculpta*, *C. vernicosa* and *C.* sp. *Blackberry* (D.M. Porter 171). However, close examination of seeds will clearly separate all five taxa. Of the above, only *C. vernicosa* (see below) is probably closely related; as it has similar seed, ovary and stigmata characters, but it is relatively easy to separate from *C. sculpta* by closely comparing the characters described.

Calandrinia vernicosa Obbens, *sp. nov.*

Structura floris *C. polyandro* Benth. affinis sed floribus grandioribus et seminis aliter colliculosis differt.

Typus: Coburn Station, Western Australia [precise locality withheld for conservation reasons], 18 August 2008, *F. Obbens, F. Hort & J. Hort* FO 04/08 (*holo*: PERTH 07957408 (sheet 1), PERTH 07957718 (sheet 2); *iso*: CANB).

Annual herb; root system a taproot with several lateral and finer roots. *Plant* decumbent to semi-erect, occasionally erect, 80–300 mm tall, 60–450 mm wide, glabrous. *Basal leaves* fleshy, narrowly obovate to obovate, occasionally spathulate, 1.5–13.4 mm wide, with a distinct, deep medial groove on adaxial surface which expresses as a midvein on the abaxial surface, green or grey-green (appearing bright and somewhat shining in sunshine); apex acute, 6.5–99 mm long. *Stems* few to several (usually 1–8), 8–140 mm long, radiating out and upwards from base. *Stem leaves* fleshy, narrowly obovate to obovate, occasionally linear or orbicular and sometimes asymmetric, to 67 mm long and 12.8 mm wide, alternate, with leaf clusters at stem ends. *Scapes* 20–125 mm long, bare. *Inflorescence axis* 35–180 mm long, bare except for a few to several ± scarious bracts opposite each flower pedicel, forming a loose cyme. *Inflorescence axis bracts* ± spreading, narrowly triangular to triangular, 2.8–8.5 mm long, 2.0–4.8 mm wide, the apex long-acuminate. *Pedicel* 15–38 mm long, erect, to 47 mm long in fruit, moderately reflexed. *Flowers* 26–42 mm diameter. *Sepals* ± thin, ovate to broadly ovate, 5.5–11.7 mm long, 5.0–6.4 mm wide, with 3 prominent veins and a distinct mucro at apex, free to base. *Petals* 5, deep bright pink adaxially, whitish or yellowish with distinct striations abaxially, broadly to very broadly obovate, occasionally orbicular, with a shallowly emarginate apex, 16.7–19.8 mm long, 13.0–17.0 mm wide, free to base. *Stamens* 59–78 in three ill-defined rows; filaments free, 1.6–4.3 mm long, attached to the top of a basal ring beneath the ovary, moderately long-papillose on lower quarter of filament on adaxial side; anthers elliptic to oblong in outline, 1.0–1.25 mm long, 0.47–0.7 mm wide, versatile, extrorse, dehiscing longitudinally. *Ovary* obovoid, 2.0–2.4 mm diameter, brown, with 3 obvious sunken grooves (valve abscission lines). *Stigmata* 3, squatly triangular becoming narrowly triangular, longer and spreading with maturity, 0.95–3.7 mm long, densely covered with moderately long stigma trichomes, free to base. *Capsule* ovoid to broadly ovoid, 4.5–7.0 mm long, 3.6–5.6 mm wide; apex obtuse, normally shorter than the sepals; valves 3, splitting from apex to base. *Seeds* 76–137, mid brown or tan, sometimes darker particularly on the papillae, with a varnish-like gloss, subreniform to reniform, 0.57–0.77 mm long, 0.35–0.70 mm wide, 0.42–0.47 mm thick; surface with four dorsal ridges formed by rows of moderately large and irregular papillae with an additional outer ridge formed on each side by elongate and raised colliculate cells, each cell with a papilla protruding from the surface while the remainder of each side surface consists of more elongated colliculate cells. (Figures 10, 11A–C)

Other specimens examined. WESTERN AUSTRALIA: [localities witheld for conservation reasons]. 23 Aug. 1991, *A.H. Burbidge* 4490 (PERTH 05043123); 28 Aug. 1991, *A.H. Burbidge* 4632 (PERTH 05020220); 18 Aug. 2008, *F. Obbens, F. Hort & J. Hort* FO 06/08 (PERTH 07957424); 18 Aug. 2008, *F. Obbens, F. Hort & J. Hort* FO 07/08 (PERTH 07957432); 21 Sep. 1994, *L. Sweedman* S3448 (KPBG).

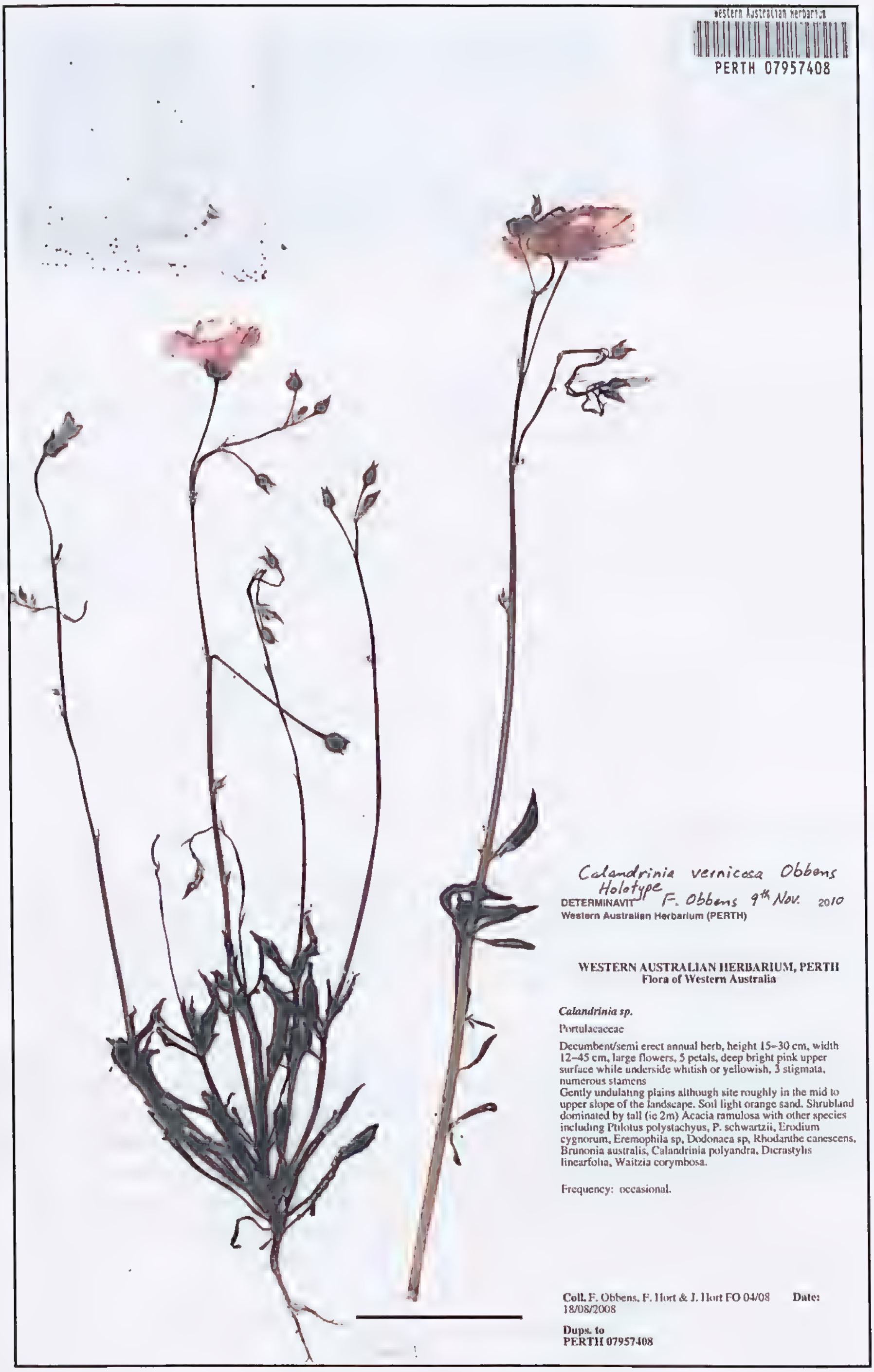
Distribution. All collections to date are from a roughly 50 km stretch of the North West Coastal Highway and adjacent areas around the Billabong and Overlander roadhouses. This area encompasses the boundary region between the Geraldton Sandplains District (South West Botanical Province) and a southern portion of the Yalgoo District (Eremaean Botanical Provience) (Figure 3).

Habitat. *Calandrinia vernicosa* occurs on undulating sandplains interspersed with low hills or ridges. The soils are either red-orange, light orange or orange-brown sandy loams as is often seen on old and vegetated dunal landscapes. It appears to have a relatively narrow habitat preference of tall *Acacia* shrubland, dominated by *A. ramulosa* and/or *A. microcalyx*, with a sparse understorey of *Eremophila* spp., *Dodonaea* spp., *Dicrastylis linearfolia* etc and annuals including *Ptilotus polystachyus* and everlasting daisy species. One collection is described as being from open low woodland over scrubs with *Melaleuca* and *Hakea* spp.

Phenology. Flowering mid August to late September.

Conservation status. There are five collections of this taxon at PERTH and one collection at KPBG. The current distribution is quite restricted; future survey may well extend the known range as there appears to be a significant amount of typical habitat yet to be explored. Recently listed as Priority Two under Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora.

Etymology. From the Latin *vernica*, referring to the 'varnished' appearance of the seed coat.



Calandrinia vernicosa Obbens
Holotype
DETERMINAVIT F. Obbens 9th Nov. 2010
Western Australian Herbarium (PERTH)

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Calandrinia sp.

Portulacaceae

Decumbent/semi erect annual herb, height 15–30 cm, width 12–45 cm, large flowers, 5 petals, deep bright pink upper surface while underside whitish or yellowish, 3 stigmata, numerous stamens
Gently undulating plains although site roughly in the mid to upper slope of the landscape. Soil light orange sand. Shrubland dominated by tall (ie 2m) Acacia ramulosa with other species including Ptilotus polystachyus, P. schwartzii, Erodium cygnorum, Eremophila sp, Dodonaea sp, Rhodanthe canescens, Brunonia australis, Calandrinia polyandra, Dicrastylis linearifolia, Waitzia corymbosa.

Frequency: occasional.

Coll. F. Obbens, F. Hort & J. Hort FO 04/08 Date: 18/08/2008

Dups. to
PERTH 07957408

Figure 10 . Part of the holotype of *Calandrinia vernicosa* (*F. Obbens, F. Hort & J. Hort* FO 04/08; PERTH 07957408). Scale bar = 5 cm.

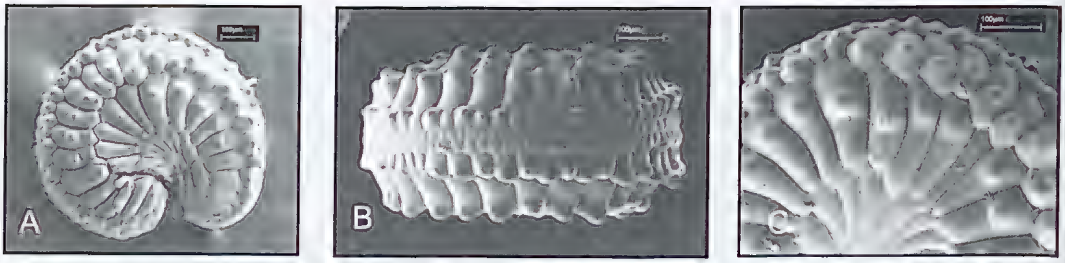


Figure 11. SEM of *Calandrinia vernicosa* seed. A – plan view; B – dorsal view; C – edge view at high magnification. Scale bar on each image.

Notes. The affinities of *Calandrinia vernicosa* are uncertain other than its likely relationship to *C. sculpta* as noted under that species. It has been confused with *C. polandra* (see notes under *C. sculpta*). In *C. sculpta* and *C. vernicosa*, abscission lines on the ovary at anthesis are clearly visible at very low magnification with these being more prominent in *C. vernicosa* because they are in slightly sunken grooves. Abscission lines in the earlier stages of ovary development in *Calandrinia* species are not normally seen or at least are not noticeable except at higher magnifications. The ovary from above of most *Calandrinia* species is generally circular in outline, but in both *C. sculpta* and *C. vernicosa* this outline is shallowly depressed at three equally spaced intervals giving the appearance of a typical three-locular ovary.

Morphological observations in *Calandrinia*

Plant habit and architecture

There is considerable variation observed within the plant habit of *Calandrinia*. Many species may be either prostrate, decumbent and/or semi-erect while others appear to remain constant. Habit variability added to a common situation of finding a number of similar *Calandrinia* species at any one location makes field identification difficult.

Apart from section *Tuberosae* (Obbens 2006), most calandrinias have an architecture comprising three main elements. The first are stems that grow and radiate out from the basal leaf rosette and generally do not branch or rise substantially above ground level. For a few species, there is occasionally an additional short central 'stem' that grows erect with a number of lateral stems arising from this vertical axis (e.g. see description *C. tholiformis*). These laterals develop features typical of stems normally derived from within the basal rosette. Stem leaves are usually held alternately or sometimes clustered. Stems frequently terminate with a compact leaf cluster and often have an obvious 'knee' or bend where the scapes begin. Where this is not obvious then the last stem leaf represents that juncture.

Scapes represent the second element in the plant architecture. Rarely, more than one scape arises from the junction point and occasionally there may be a few rudimentary leaves running up the lower portion of the scape. Scapes rarely branch and if so usually only once.

The final element is the inflorescence axis. This arises at the end of the scape beginning at the lowest fertile bract and pedicel opposite the bract. Even if a pedicel only produces a rudimentary bud which does not mature, it is still considered to mark the beginning of the flowering axis. Thus the full 'radiating arm' unit consists of a stem attached to a scape and that attached to an inflorescence axis (Figure 12).

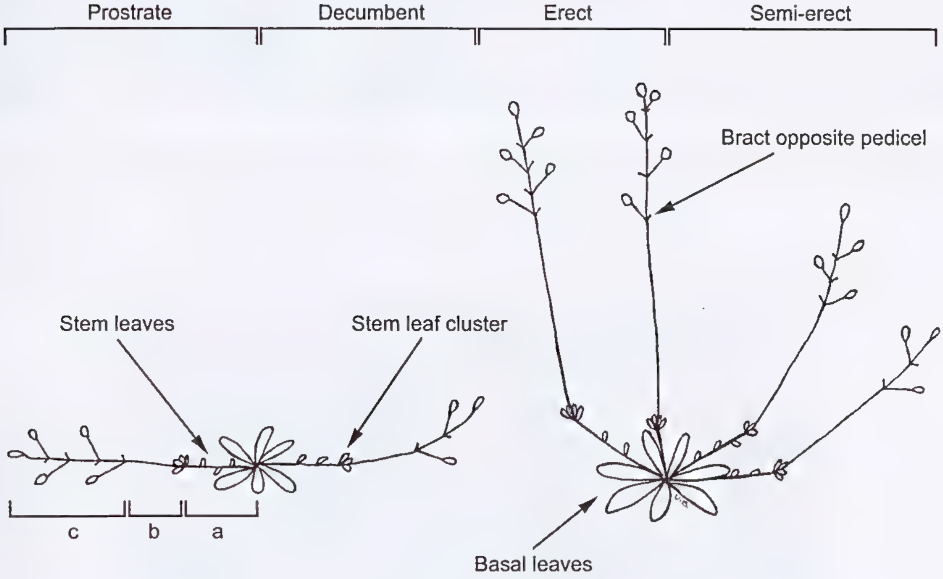


Figure 12. *Calandrinia* plant habits and architecture. a – stem; b – scape; c – inflorescence axis.

Stamen arrangements and basal ring

Stamens in *Calandrinia* arise from the upper edge of a basal ring which subtends the ovary. The basal ring comprises a thin, narrow ring of tissue which is frequently obscured by the lower portion of the ovary. Close examination of the basal ring and attached staminal filaments reveals that there are a wide variety of diagnostic features, including basal ring width, staminal number, staminal lengths, staminal insertion point/shape, staminal series positioning and differences in other associated structure such as nectaries. Examination of spirit collections of about 20 *Calandrinia* species reveals some broad differences; other variations are likely to occur with further investigation of this genus.

Flowers with numerous stamens (i.e. > 30) have three, sometimes four, ill-defined rows crowded on top or slightly aside the top of the basal ring. This arrangement often occurs in species with medium-sized to large-sized flowers, and includes three of the five species described above (*C. pentavalvis, C. sculpta* and *C. vernicosa*). Melville (1959) described this stamen arrangement for *C. polyandra*, although the accompanying illustration did not show it clearly.

In medium-sized to smaller-flowered species (i.e. < 30 stamens) there is substantial variation in stamen and basal ring configurations. Flowers with ~12–30 stamens often have two rows of equally spaced stamens, the inner and outer series commonly alternating and sometimes of different lengths. *Calandrinia creethae* Morrison (12 stamens) has this arrangement, with an unusually wide basal ring that envelops the lower third or less of the ovary. In this species the longer inner series is attached to the top of the ring while the shorter outer series is attached lower down on the side wall of the ring. *Calandrinia stagnensis* J.M.Black (8–11 stamens published, although in Western Australia up to 15 stamens) has a similar arrangement with a narrower basal ring and fewer stamens within the outer series. These two species also have similar stigmata, capsule shape and seeds and may be closely related. In contrast to the above, *C. polypetala* Fenzl with 12 stamens has only one series of stamens all equally spaced and all of equal length.

In medium-sized or smaller flowers with less than 12 stamens the usual configuration is a single row of stamens on top of the basal ring, with alternating short and long filaments (see description of *Calandrinia flava* above and Figures 13A–C). Once again, there are exceptions such as *C. liniflora* which has an inner series of five stamens and an outer series of five (sometimes six and four respectively). *Calandrinia liniflora* also has a relatively wide basal ring with the inner series of stamens equally spaced around a slightly undulate rim and the outer series equally spaced and attached lower on the side wall of the basal ring.

Several species have very small flowers (i.e. usually < 5 mm diameter) with few stamens in one row equally spaced around the ovary. *Calandrinia corrigioloides* (three stamens) is a typical example. *C.* sp. *Bungalbin* (G.J. Keighery & N. Gibson 1656) is unusual in having three stamens equally spaced and inserted at the apex of basal lobes rather than a continuous basal ring. These lobes are partially adnate to the base of adjacent petals and appear to be disconnected from each other. Two other small-flowered species examined, *C.* sp. *Piawaning* (A.C. Beauglehole 12257) and *C.* sp. *The Pink Hills* (F. Obbens FO 19/06), have five and three stamens respectively, both with one row of equally spaced filaments. These species also have some other unusual characters such as coriaceous, one or two-seeded, indehiscent and deciduous capsules with valve rudiments at the apex. These two species, along with *C. disperma* J.M.Black which has many similar attributes (very small flowers, four or five stamens, coriaceous capsules with two seeds, one of which is released and one retained in the deciduous capsule) appear morphologically anomalous within *Calandrinia.*

All species examined, are papillose to some degree on the lower portion of the filament facing the ovary, and sometimes also on the basal ring.

Stigmata morphology

Stigmata in *Calandrinia* are generally described as plumose (Bentham 1863, Morrison 1912, Black 1927, Obbens 2006) although Melville (1959) used the term 'glandular papillose'. High magnifications reveal that the stigmata are mostly covered with trichomes, each with a slightly bulbous apex. It is probable that viscous substances produced from stigmatic glands exude onto the trichomes and this aids the capture of pollen grains, as readily observed in the field.

An examination of 20 *Calandrinia* species showed significant variation in stigmata characteristics such as shape, cross-section, colour and trichome length and density. The stigmata for *C. sculpta* and *C. vernicosa* (Figure 14A–D) are very similar being triangular. *Calandrinia polyandra, C. remota* and

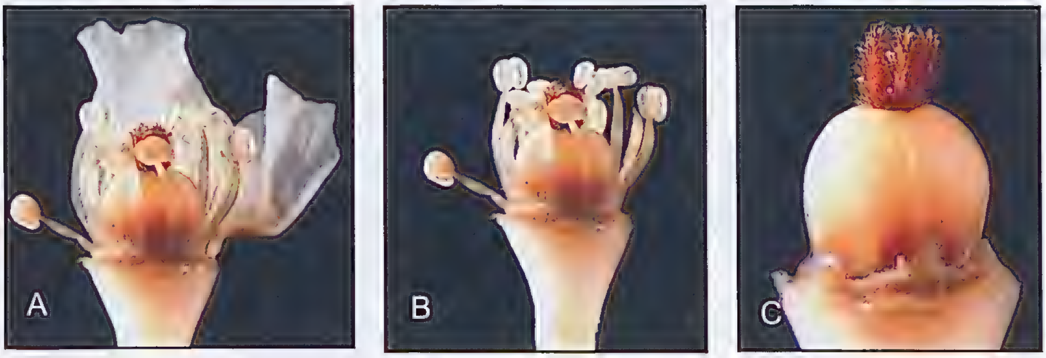


Figure 13. *Calandrinia flava* flower structure. A – single row of stamens with a few petals removed; B – with all petals removed (tapering filaments and nectaries near basal ring); C – with all petals and stamens removed (stigmata at early stage of maturation).

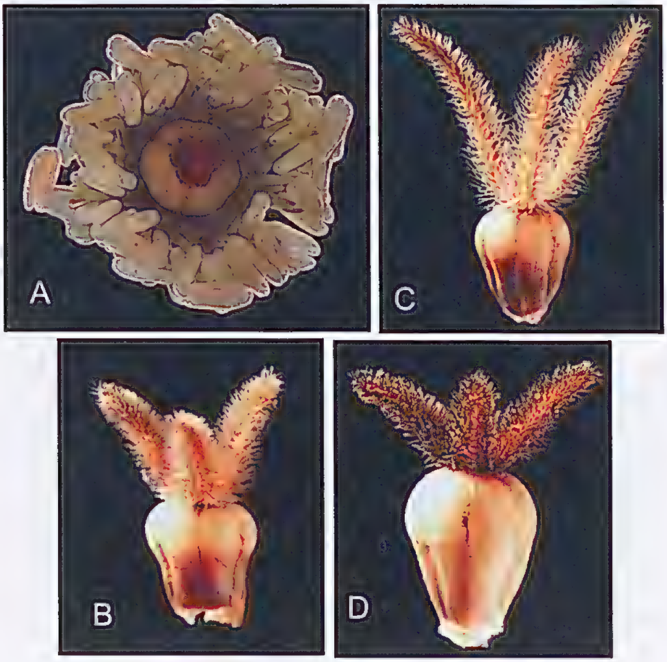


Figure 14. *Calandrinia vernicosa* flower structure and stigmata maturation. A – stigmata maturation at early development stage showing the plan view of staminal whorl, ovary and stigmata; B – stigmata maturation at intermediate development stage. C – stigmata maturation at late development stage; D – *Calandrinia sculpta* stigmata at intermediate development stage.

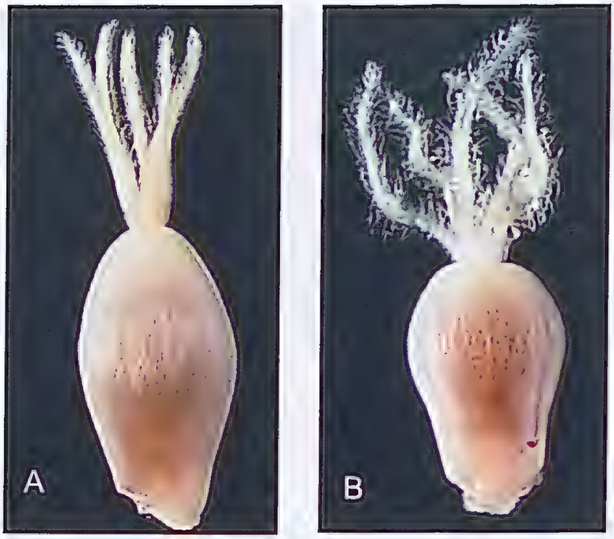


Figure 15. *Calandrinia pentavalvis* stigmata maturation. A – stigmata maturation at early to intermediate development stage; B – stigmata maturation at late development stage.

C. sp. Meckering (F. Obbens 42/02) also have relatively similar triangular stigmata. Trichome length and density differs somewhat for all five species listed above. *Calandrinia pentavalvis* is markedly different to the above in having linear stigmata with moderately long trichomes (Figure 15A, B). *Calandrinia flava* has short stigmata, incurved at the apex although these slightly diverge with maturity (Figure 13). There are other stigmata variations and further examination of the genus would probably highlight this to a greater extent.

Protandry appears common amongst the mid-sized to large flowered species of *Calandrinia*, the sequence of events occurring relatively quickly (Figures 14, 15). First, pollen is released from the extrorse anthers then the immature stigmata begin to grow dramatically (some to triple their original length). The stigmatic arms diverge becoming increasingly more receptive while the appressed stigmatic trichomes slowly spread at maturation to maximize capture of incoming pollen. The use of nectaries to attract pollinators and protandry are strategies to maximize outcrossing. This concurs with Carolin's (1993) *pers. comm.* from J. West that, '*Calandrinia* spp. with large flowers and large numbers of stamens are self-incompatible, whilst those with small flowers and small numbers of stamens are self-compatible.'

Acknowledgements

I would like to express my gratitude to Kevin Thiele, Judy West, Mike Hislop and Paul Wilson for reviewing drafts of this paper. Additional thanks to Paul Wilson for the Latin diagnosis. Thanks also to John Kuo from The University of Western Australia's Centre of Microscopy for the SEM seed images, Una Bell for drawing figure 12, Alex Williams for assistance with macro-photography on figures 13, 14 and 15 and to the many other colleagues and volunteers at the Western Australian Herbarium who have helped in many ways with this voluntary project.

References

Black, J.M. (1927). Additions to the flora of South Australia No. 25. *Transactions and proceedings of the Royal Society of South Australia* 51: 378–385.

Bentham, G. (1863). *Flora Australiensis.* Vol. 1, pp. 171–177 (Lovell Reeve: London.)

Carolin, R. (1993). Portulacaceae. *In:* Kubitzki, K., Rohwer, J.G. & Bittrich, V. (eds) *The families and genera of vascular plants.* Vol 2, pp. 544–555. (Springer Verlag: Berlin.)

Melville, R. (1959). Contributions to the flora of Australia.V. The identity of *Calandrinia polyandra* Bentham. *Kew Bulletin* 13: 400–401.

Morrison, A. (1912). New and rare West Australian plants. *The Journal of Botany, British and foreign* 50: 164–168.

Obbens, F. (2006). A review of the tuberous *Calandrinia* species (section *Tuberosae*), including three new species for Western Australia. *Nuytsia* 16(1): 95–115.

Wurmbea fluviatilis (Colchicaceae), a new riverine species from the Gascoyne region of Western Australia

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Abstract

Macfarlane, T.D. & Case, A.L. *Wurmbea fluviatilis* (Colchicaceae), a new riverine species from the Gascoyne region of Western Australia. *Nuytsia* 21(1): 25–30 (2011). A new species of *Wurmbea*, *W. fluviatilis* T.Macfarlane & A.Case, is described and illustrated with photographs and a distribution map. The new species is known from only three populations from the Gascoyne River catchment in the region of Mount Augustus, growing on river banks and beside riverside pools. It is a relatively tall, attractive species with bi-coloured flowers.

Introduction

A number of new species of *Wurmbea* Thunb. (Colchicaceae) have been discovered in Western Australia in recent years, most of them in the more arid regions outside of the better-collected south-west of the State. Following on from the description of *W. inflata* (Macfarlane & Case 2007), this is the second species to be described recently from the Gascoyne region. *Wurmbea* has been extensively studied taxonomically in Australia (Macfarlane 1980, 1987; Bates 1995, 2007) so the recent surge in discoveries is surprising, but is a consequence of targeted field work in under-collected areas at appropriate times.

The new species described here was first collected during unrelated fieldwork by R.J. Chinnock in 1986 and lodged in the South Australian Herbarium (AD), where it was identified as *Wurmbea deserticola* T.Macfarlane by R.J. Bates in 1994. In 1996 A.L. Case with colleague Bill Cole independently found it at a second location while engaged in field work for a study of sexual systems in *Wurmbea* (Barrett & Case 2006, Case *et al.* 2008), immediately recognised it as a new species, and soon after saw the Chinnock specimen at AD. Subsequent field work by T.D. Macfarlane, A.P. Brown and C.J. French has improved our understanding of the species but has not revealed any more populations other than one casually recorded photographically by A.P. Brown and J. Brown in 2006.

Description

Wurmbea fluviatilis T.Macfarlane & A.Case, *sp. nov.*

Wurmbea monanthae (Endl.) T. Macfarlane similis sed floribus plus numerosis, centro floris atroroseo, habitatione riparia differt.

Typus: Gum Creek, [Mt Augustus Station], Western Australia, 29 June 2006, *T.D. Macfarlane, A.P. Brown & C.J. French* TDM 3889 (*holo*: PERTH 08230447, *iso*: CANB, MEL).

Wurmbea sp. Thomas River A. Case & B. Cole 58, Western Australian Herbarium, in *FloraBase* http://florabase.dec.wa.gov.au/ [accessed November 2010].

Plants tall, 15–55 cm tall. *Corms* not studied. *Leaves* 3, well-spaced apart, lower two dissimilar, sometimes relatively shortly but still distinctly separated. *Lowest leaf* basal, from 2/3 to almost equalling the top of the inflorescence, lamina channelled, broad, 2–4 mm wide in the lower part, not dilated or slightly to noticeably dilated at base, more or less linear but gradually tapering to a fine apex. *Second leaf* with a tubular sheath 2–3 cm long, the lamina base markedly dilated, the remainder of the lamina, up to 10 times as long as the dilated part, relatively broad at the base and tapering evenly to fine apex, erect, usually reaching to the inflorescence, occasionally exceeding it. *Third leaf* with the tubular sheath long, the sheath/lamina transition strongly dilated for 2.5–3.5 cm, narrowing rather abruptly to the tapering acute distal part of the lamina which is shorter than or up to 3 times as long as the dilated part, erect, only occasionally reaching to the lower flowers. Peduncle long, (2)6–8 cm. *Inflorescence* an open spike of 3–10(–13) flowers, the lower internodes 5–20 mm long. *Flowers* all hermaphrodite or occasionally the uppermost male, bicoloured, dark pink at centre including the tepal claws and the nectaries but not including the proximal part of the staminal filaments, the remainder white to very pale pink. *Tepals* 6, 8–9 mm long, connate very shortly at the base for 0.5–1 mm (1/16–1/9 of their length), narrow below the nectary, broadening abruptly above it to form a broadly elliptical to sub-orbicular widely spreading limb, the apex obtuse to rounded. *Nectary* one on each tepal, at or slightly below 1/3 from the base, a curved, thickened and rather rigid structure with shelf-like projections on either side, continuous across the tepal from margin to margin, the distal margin indistinct, curving or moulded around the filament and appearing to clasp it when dried. *Stamens* 6, 2/3 as long as the perianth; filament adnate to the perianth well beyond the perianth tube and extending almost to the nectary, not swollen in lower part, tapering gradually to the anther attachment; anther oblong, 1.7–1.8 mm long, attached at or below the middle, dehiscing by longitudinal slits, dark red. *Ovary* obloid to ellipsoid, 2.6–3 mm long at anthesis; carpels 3, connate at the axis to the apex, the wings free but appressed to each other, with *c.* 22–24 ovules per locule; styles 3, clearly delimited from ovary, shorter than to about equal in length to the ovary at anthesis, connate at the base for a short distance (for *c.* 0.25 mm at anthesis), straight, slightly spreading, remaining straight with age; stigmas short, terminal. *Fruiting inflorescence* erect. *Capsules* obloid in outline, angled, moderately enlarged, not greatly exceeding perianth remains, not becoming inflated. (Figure 1)

Other specimens examined. WESTERN AUSTRALIA: [localities generalised for conservation reasons] Gum Creek, Mt Augustus Station, 22 Aug. 1986, *R.J. Chinnock* 6873 (AD); Thomas River, [Cobra Station], 27 July 1996, *A. Case & B. Cole* 58, (PERTH); Thomas River, 21 June 1999, *T.D. Macfarlane & R. Davis* TDM 3314 (PERTH); Thomas River, 29 June 2006, *T.D. Macfarlane, A.P. Brown & C.J. French* TDM 3891 (PERTH).

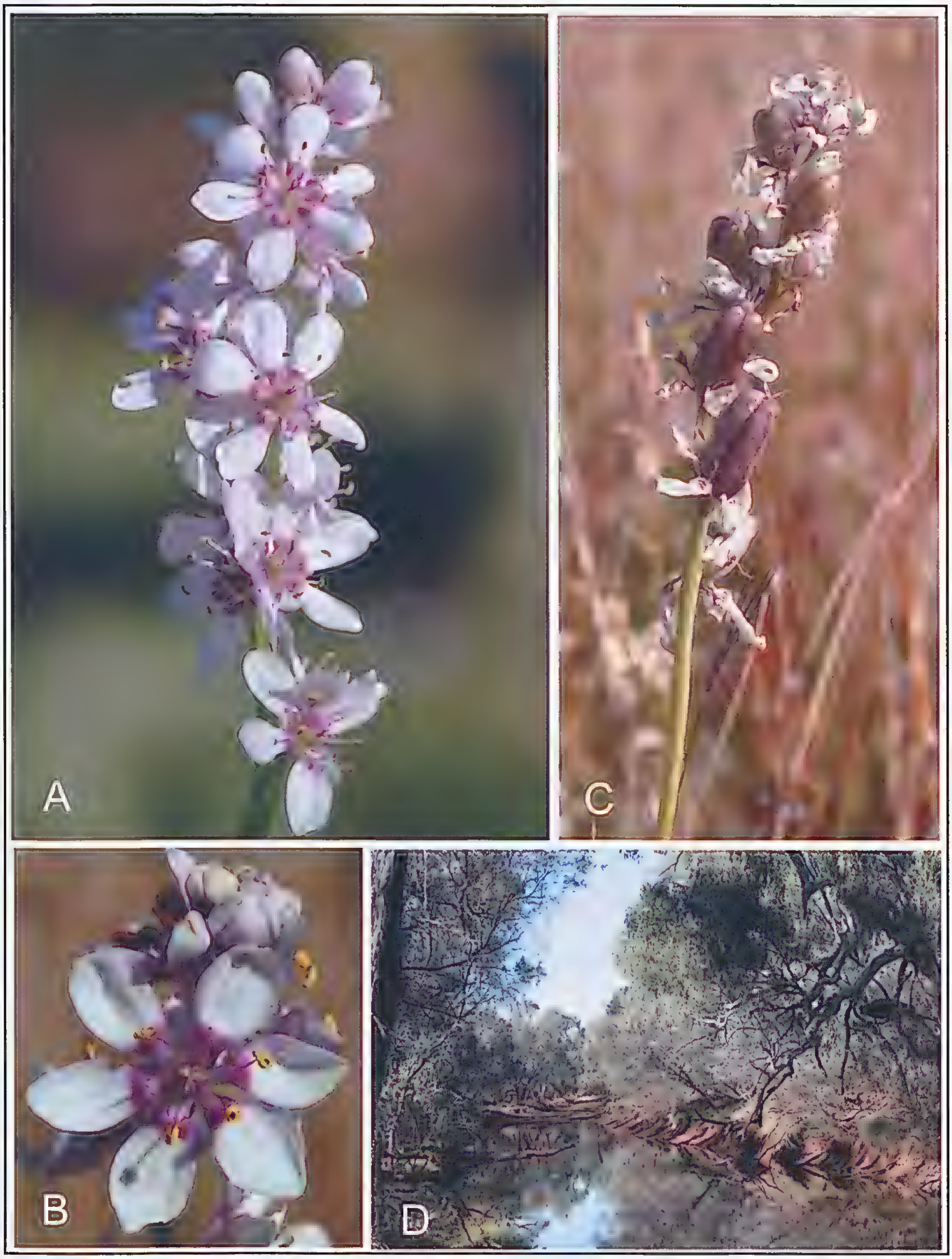

Figure 1. *Wurmbea fluviatilis*. A – flowering inflorescence; B – flower enlargement (some anthers lost); C – fruiting inflorescence; D – habitat, banks adjacent to river pool, Gum Creek. Photos: A, B, D – A.P. Brown. C – T.D. Macfarlane.

Distribution and habitat. Western Australia, Gascoyne IBRA Bioregion (Department of the Environment, Water, Heritage and the Arts 2010), known from only three locations, one each on the Thomas and Lyons rivers and Gum Creek (Figure 2). This represents a total range of 74 km. *Wurmbea fluviatilis* grows in damp soils of clay or sandy-clay on banks of river pools and river terrace pools, sometimes growing in water at the edges of shallow pools. Associated vegetation at Thomas River was a dense perennial grassland of *Eriachne* sp. with scattered trees of *Eucalyptus camaldulensis*, at Gum Creek a closed woodland of *E. camaldulensis* and *Acacia* spp. with a dense ground layer of mainly grasses and sedges and at Lyons River scattered *Eucalyptus camaldulensis* and *Acacia* spp. over sedges and annuals. The sites are beside seasonal watercourses and become flooded during wet periods with water persisting in the pools for an extended period.

Phenology. Flowers in June to August of years when there has been sufficient rainfall.

Conservation status. Listed as Priority Two under the Department of Environment and Conservation (DEC) Conservation Codes for Western Australia under the phrase name *Wurmbea* sp. Thomas River A. Case & B. Cole 58 (Smith 2010; Western Australian Herbarium, *FloraBase*, 1998–, accessed Nov. 2010). Only three localities are known despite some effort in seeking further localities, although only sites easily accessible by road have been examined to date. Whilst other locations may well exist, the

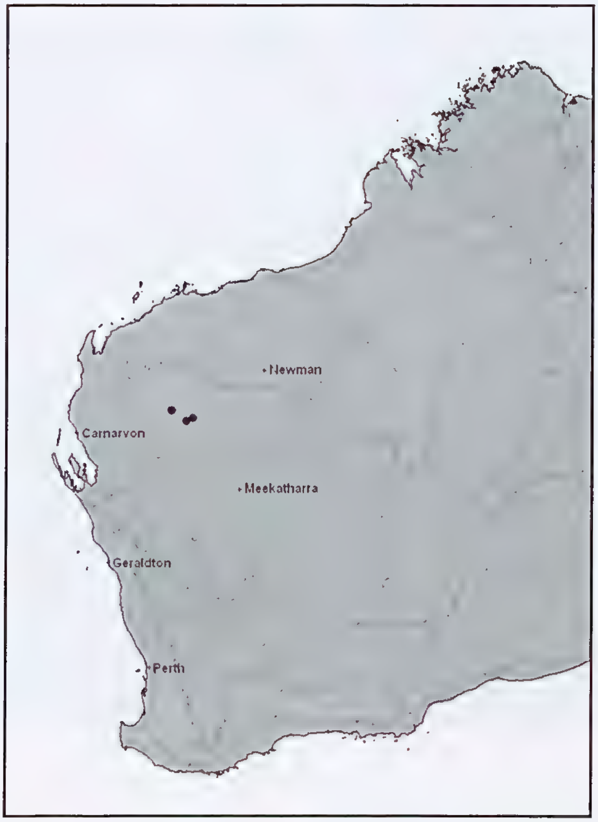

Figure 2. Map of Western Australia showing the distribution of *Wurmbea fluviatilis* and IBRA Bioregion boundaries.

species is clearly not distributed continuously along the watercourses, and it is vulnerable to threats such as weed invasion or potential heavy cattle use of river pools. However the Thomas River site is on land managed for conservation by DEC and the Gum Creek site is in good condition even though on a pastoral station; there is no detailed information for the Lyons River site.

Etymology. The specific epithet *fluviatilis* is from a Latin adjective meaning pertaining to rivers, in reference to the riverside habitat of this species.

Notes. Wurmbea fluviatilis is most similar to *W. monantha* (Endl.) T.Macfarlane in the form of the nectaries and their contrasting colour with the majority of the perianth, in the staminal filaments adnate to the tepal claw almost to the nectary and well beyond the fused part of the perianth, and in the style bases close together and usually shortly connate. They are both multi-flowered plants with hermaphrodite flowers and an erect fruiting peduncle. They differ in distribution, *W. monantha* being mainly coastal, especially favouring calcareous soils, and absent from the Gascoyne region; in habitat, *W. monantha* sometimes growing in damp situations but more often in drier sites whereas *W. fluviatilis* is associated with river banks and pools; and morphology, with *W. fluviatilis* usually having more flowers per plant and the perianth being a deeper pink in the centre with the colour not restricted to the nectary as it is in *W. monantha.*

Wurmbea fluviatilis plants are sometimes growing in water while flowering. This taxon is one of several which grow in water, including *W. murchisoniana* T. Macfarlane, *W.* sp. Cranbrook (A.R. Annels 3819) and the South Australian and Victorian *W. dioica* (R.Br.) F.Muell. subsp. *lacunaria* R.Bates (Bates 1995). None of these have the rigid curved nectary moulded around the filament as in *W. fluviatilis.*

No other *Wurmbea* species have been seen growing with *W. fluviatilis* although *W. inflata* grows in the same region, albeit in the very different habitat of rock scree on hillsides, and with its overall pink flowers, two separate, obscure, concolorous nectaries and often decumbent infructescences with inflated fruits, its morphology is very different (Macfarlane & Case 2007).

Acknowledgements

TM thanks Andrew Brown and Chris French who have helped to investigate *Wurmbea fluviatilis* through discussion, sharing the work and cost of field trips, and for photography. Andrew Brown also recognised that a photo by his son Justin represented a third population of the species and provided site information. AC thanks Spencer Barrett for support, Bill Cole for field work assistance and the Director of the South Australian Herbarium (AD) for access to the collections during a visit. Thanks to Paul Wilson for revising the Latin diagnosis. The field work was partly funded by the Department of Environment and Conservation and partly by the University of Toronto.

References

Barrett, S.C.H. & Case, A.L. (2006). The ecology and evolution of gender strategies in plants: the example of Australian *Wurmbea* (Colchicaceae). *Australian Journal of Botany* 54: 417–433.

Bates, R.J. (1995). The species of *Wurmbea* (Liliaceae) in South Australia. *Journal of the Adelaide Botanic Gardens* 16: 33–53.

Bates, R.J. (2007). A review of South Australian *Wurmbea* (Colchicaceae~Liliaceae): keys, new taxa and combinations, and notes. *Journal of the Adelaide Botanic Gardens* 21: 75–81.

Case, A.L. & Barrett, S.C.H. (2004). Floral biology of gender monomorphism and dimorphism in *Wurmbea dioica* (Colchicaceae) in Western Australia. *International Journal of Plant Sciences* 165: 289–301.

Case, A.L., Graham, S.W., Macfarlane, T.D., and Barrett, S.C.H. (2008). A phylogenetic study of evolutionary transitions in sexual systems in Australasian *Wurmbea* (Colchicaceae). *International Journal of Plant Sciences* 169: 141–156.

Department of the Environment, Water, Heritage and the Arts (2010). Australia's bioregions (IBRA). http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html#ibra [accessed Feb. 2011]

Macfarlane, T.D. (1980). A revision of *Wurmbea* (Liliaceae) in Australia. *Brunonia* 3: 145–208.

Macfarlane, T.D. (1987). *Wurmbea*. *In*: George, A.S. (ed.). *Flora of Australia*. Vol. 45. (Australian Government Publishing Service: Canberra.)

Macfarlane, T.D. & Case, A.L. (2007). *Wurmbea inflata* (Colchicaceae), a new species from the Gascoyne region of Western Australia. *Nuytsia* 17: 223–228.

Smith, M.G. (2010). Declared Rare and Priority flora List for Western Australia. (Department of Environment and Conservation: Kensington, WA.

Western Australian Herbarium. (1998–). *FloraBase – The Western Australian flora*. Department of Environment and Conservation. http://florabase.dec.wa.gov.au/ [accessed Feb. 2011]

SHORT COMMUNICATIONS

Valid publication of *Ptilotus stirlingii* subsp. *australis* (Amaranthaceae)

In an oversight in a paper (Davis & Butcher 2010) resolving the status of infraspecific taxa in *Ptilotus stirlingii* (Lindl.) F.Muell., the Latin diagnosis for the new subspecies *Ptilotus stirlingii* subsp. *australis* R.W.Davis & R.Butcher was omitted, thereby rendering the name invalidly published under the International Code of Botanical Nomenclature. This omission is rectified here, and the new subspecies formally described.

Ptilotus stirlingii subsp. **australis** R.W.Davis & R.Butcher, *subsp. nov.*

Ptiloto stirlingii (Lindl.) F.Muell. subsp. *stirlingii* affinis sed habito prostrato, bracteis longioribus 5.3–7.5 mm longis (in *stirlingii* 1.8–4.5 mm) et bracteolis 5.4–6.3 mm longis (in *stirlingii* 3–5 mm) distinguendo.

Typus: 6.3 km north along track from Melaleuca Road, *c.* 43 km north-north-west of Munglinup, Western Australia, 33° 20' 55.3" S, 120° 39' 10.3" E, 12 December 2005, *R. Davis* 10956 (*holo*: PERTH 07256361; *iso*: CANB, K).

Ptilotus stirlingii (Lindl.) F.Muell. var. *minutus* Benl, Mitt. Bot. Staatssamml. München 6: 503 (1967). Type: Grass Patch, Western Australia, October 1931, *W.E. Blackall* 1028 (*holo*: PERTH!; *iso*: PERTH!).

Ptilotus stirlingii (Lindl.) F.Muell. var. *laxus* (Benth.) Benl, Mitt. Bot. Staatssamml. München 6: 500 (1967). *Trichinium laxum* Benth., *Fl. Austral.* 5: 232 (1870); *Ptilotus laxus* (Benth.) F.Muell., *Syst. Census Austral. Pl.* 1: 28 (1882). *Type*: between Cape Le Grand and Cape Pasley, Western Australia, *G. Maxwell s.n.* (*holo*: MEL *n.v.*; *iso*: BM *n.v.*, K (image!); MEL *n.v.*).

Prostrate *perennial herb* to 8 cm high. *Stems* terete, ribbed, sparsely hairy. *Cauline leaves* narrowly elliptical or oblanceolate to obovate, 5–30 mm long, 2–7 mm wide, glabrous to sparsely hairy. *Inflorescences* ovoid to shortly cylindrical, 20–37 mm long, 22–28 mm wide; *bracts* narrowly ovate, 5.3–7.5 mm long; *bracteoles* broadly ovate to obovate, 5.4–6.3 mm long. *Outer tepals* 10–14 mm long; *inner tepals* 10.5–13.5 mm long; *staminal cup* 2.5–3 mm long; *style* 3.5–5.1 mm long; *ovary* glabrous. *Seed* slightly glossy, brown, to 1.8 mm long.

Distribution and habitat. Distributed through a large part of the Esperance Plains IBRA region, where it is mostly found in coastal areas, although extends as far inland as the Stirling Range and Grasspatch. Occurs in heathlands and mallee woodlands on deep sands to gravelly loams.

Phenology. Flowering from late October though to January.

Notes. *Ptilotus stirlingii* subsp. *australis* is poorly collected but from the material available it appears to be reasonably consistent morphologically. Field observations suggest that it may only be abundant after fire, perhaps accounting for the relatively few collections.

Acknowledgements

Thanks to Paul Wilson for the Latin diagnosis and for bringing its previous absence to our attention.

References

Davis, R.W. & Butcher, R. (2010). The status of infraspecific taxa and new subspecies in *Ptilotus stirlingii* (Amaranthaceae). *Nuytsia* 20: 261–270.

Robert W. Davis and Ryonen Butcher

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Removal of the informal name *Epiblema grandiflorum* var. *cyaneum* ms from the Census of Western Australian Plants

Epiblema grandiflorum R.Br. var. *cyaneum* K.W.Dixon ms was discovered by members of the West Australian Native Orchid Study and Conservation Group in 1984 (Brown *et al.* 2008) and was added to the *Census of Western Australian Plants* (Western Australian Herbarium 1998–) as an unpublished name in 1996 to encompass a small population of sky-blue-flowered plants of the widespread, normally lilac-blue to deep mauve-flowered *E. grandiflorum*. The sky-blue-flowered plants were known only from a small, seasonal wetland dominated by sedges beneath *Melaleuca preissiana* Schauer and *M. rhaphiophylla* Schauer in Beechboro, a northern suburb of Perth on the Swan Coastal Plain, where they grew in low numbers intermixed with normally-coloured plants of *E. grandiflorum*.

Epiblema grandiflorum var. *cyaneum* ms was declared as Rare Flora in 1991 (as *E. grandiflorum* var. *caeruleum* ms) and as Critically Endangered in 1997, under the *Wildlife Conservation Act 1950* (Atkins 2007), on account of its narrow geographic range and continuing population decline. The *c.* 4 ha wetland where it occurs was gazetted as a Nature Reserve under the management of the Department of Conservation and Land Management (now the Department of Environment and Conservation) in early 1998, when the surrounding area was developed for housing. Interim Recovery Plans were subsequently prepared and a range of management actions proposed, some of which have been implemented (Stack *et al.* 2000; Luu & English 2004).

Despite these measures, *E. grandiflorum* at the site has declined, probably as a result of changes in hydrology and fire regime following urban development of the surrounding area (Stack *et al.* 2000). Surveys for *Epiblema* during its summer flowering season between 2008 and 2010 by the present author failed to locate any plants in the reserve. Dormant or non-flowering plants may still be present at the site.

In a manuscript intended to formally describe *E. grandiflorum* var. *cyaneum* (Dixon, unpublished), the only difference given between the variety and typical *E. grandiflorum* was flower colour. The diagnosis intended for the taxon was as follows:

> *Differs from* Epiblema grandiflorum *in the sky blue colour of the flowers and distinct dark blue ocelli on petals and sepals.*

No other morphological differences were noted, and the description given matches well with that of the typical form. The dark ocelli noted are also found on typically-coloured *E. grandiflorum* but are more prominent on var. *cyaneum* ms due to the paler ground-colour of the perianth. Stack *et al.* (2000: 14) noted:

> *The obvious feature which distinguishes* Epiblema grandiflorum *var.* cyaneum *from [...]* Epiblema grandiflorum *var.* grandiflorum, *is its delicate pale blue colour. Otherwise both orchids are similar in shape and share the same habitat requirements.*

Subsequent to the recognition of the var. *cyaneum* ms plants at Beechboro, a population of *E. grandiflorum* near Walpole was found with a wide range of colour variants including purple, mauve, pink and violet (Brown *et al.* 2008). Originally considered to represent var. *cyaneum* ms, none of the plants in the Walpole population have the same blue shade as the Beechboro plants, and they are now considered to be variants of typical *E. grandiflorum* (Brown *et al.* 2008).

Colour variants are common in many plant species throughout the world, occurring either as single individuals, as small populations intermingled with typically-coloured individuals, or as geographically correlated variants. The genetic basis for differing colour variants is rarely understood, but includes single gene mutations interrupting or modifying pigment metabolic pathways (e.g. Cooley & Willis 2009). Colour variants are frequently not genetically isolated from each other, and may arise spontaneously as 'sports'.

In the case of *E. grandiflorum* var. *cyaneum* ms, an unpublished genetic analysis based on very limited sampling compared 93 AFLP markers between a single individual of var. *cyaneum* ms and four typically-coloured individuals growing in close proximity to it at the Beechboro site (S. Krauss, pers. comm.). The var *cyaneum* ms plant was no more different from the four typical plants than they were from each other, suggesting little or no genetic differentiation of the blue-flowered plants.

Many colour variants occur within the Western Australian flora. For example, *Kunzea pulchella* (Lindl.) A.S.George has predominantly red-flowered, predominantly white-flowered and mixed populations, and many *Thelymitra* J.R.Forst. & G.Forst. species such as *T. macrophylla* Lindl. are variable in their colouration, with blue, white, pink and purple-flowered plants often found growing together. *Epiblema grandiflorum* is a species known to vary in colour throughout its range, sometimes markedly (as in the Walpole population). While conservation of unusual variants of any plant species is desirable, taxonomic recognition of such variants is not warranted unless evidence is available that they represent genetically distinct evolutionary lineages. Geographically restricted variants such as *E. grandiflorum* var. *cyaneum* ms are no more likely to warrant taxonomic recognition than widespread and common variants. Removal of *Epiblema grandiflorum* var. *cyaneum* ms from the *Census of Western Australian Plants* is recommended.

References

Atkins, K.J. (2007). *Declared Rare and Priority Flora List for Western Australia.* (Department of Environment and Conservation: Kensington, WA.)

Brown A., Dundas P., Dixon K. & Hopper S. (2008). *Orchids of Western Australia.* (University of Western Australia Press: Nedlands, WA.)

Cooley, A.M. & Willis, J.H. (2009). Genetic divergence causes parallel evolution of flower color in Chilean Mimulus. *New Phytologist* 183: 729–739.

Dixon, K.W. (unpublished). A new variety of *Epiblema grandiflorum* (Orchidaceae) from Perth, Western Australia.

Luu, R. & English, V. (2004). Blue Babe-In-The-Cradle orchid (*Epiblema grandiflorum* var. *cyaneum* ms.) Interim recovery plan 2004–2009. (Department of Conservation and Land Management: Perth.)

Stack, G., Brown, A. & English, V. (2000). Blue Babe-In-The-Cradle orchid (*Epiblema grandiflorum* var. *cyaneum* ms.) Interim recovery plan 2000–2003. (Department of Conservation and Land Management: Perth.)

Western Australian Herbarium (1998–). *FloraBase—the Western Australian Flora.* Department of Environment and Conservation. http://florabase.dec.wa.gov.au.

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New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid

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Abstract

Rye, B.L., Hislop, M., Shepherd, K.A. & Hollister, C. New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid. *Nuytsia* 21(2): 35–67 (2011). Four additional species are recognised in the genus *Petrophile* R.Br. ex J.Knight by the reinstatement of *P. axillaris* Meisn. and the description of three new species, *P. globifera* Hislop & K.A.Sheph., *P. foremanii* Hislop & Rye and *P. septemfida* Rye & K.A.Sheph. A hybrid between *P. ericifolia* R.Br. and *P. seminuda* Lindl. is documented, the new subspecies *divaricata* Hislop & K.A.Sheph. is named for *P. conifera* Meisn., and a lectotype is selected for *P. seminuda* var. *indivisa* Benth. There is also a key for members of the genus occurring in Western Australia, excluding those belonging to *Petrophile* sect. *Arthrostigma* (Endl.) Kuntze.

Introduction

Petrophile R.Br. ex J.Knight is an endemic Australian genus belonging to the Proteaceae subfamily Proteoideae. A suprageneric classification of the family based on molecular data (Weston & Barker 2006) places *Petrophile* together with the small South African genus *Aulax* Berg. in tribe Petrophileae.

One large Western Australian section of *Petrophile*, *P.* sect. *Arthrostigma* (Endl.) Kuntze, has recently been reviewed, with seven additional species named or reinstated (Hislop & Rye 2002; Rye & Hislop 2005). Pollen presenter characters proved to be of particular importance both in defining sect. *Arthrostigma* and in distinguishing its members. In the remainder of the genus, the main progress has been the description of one new species (Cranfield & Macfarlane 2007), the informal reinstatement of *P. axillaris* Meisn. on the *Census of Western Australian Plants* (Western Australian Herbarium 1998–) and the allocation of informal names to several new taxa. Identification of Western Australian members of the genus should soon be greatly enhanced by the release of an interactive key (Hollister *et al.* in prep.).

The objective of the current study was to provide a key to all species occurring in sections other than sect. *Arthrostigma* and to name any new Western Australian members of those sections. In *Petrophile* sect. *Arthrostigma* there remains one incompletely resolved group, the *P. brevifolia* R.Br. complex, which was examined in an honours project by Natalie Murdoch (UWA) in 2008, indicating that several new taxa needed to be recognised. One member of that complex, *P. latericola* Keighery, has now been described (Keighery 2010). The current study brings the total number of species recognised in the genus to 66.

Materials and methods

Holotypes of all the taxa described in this paper are housed at PERTH. The terminology used here is as in two earlier papers (Hislop & Rye 2002; Rye & Hislop 2005) except that the bracts subtending the flowers, which later harden to become the cone scales of the fruiting stage, are referred to here as floral bracts while they are still in the flowering stage.

Measurements of the length of the pollen presenter were taken from the base of the swelling to the stigma, although there is often a short distance below the stigma that is unmodified from the style, referred to in the descriptions below as the unswollen or glabrous apical region. The receptive part of the pollen presenter, i.e. the region where the pollen is actually deposited, corresponds in almost all cases to a region of hairs, which may occur on or above the swelling, although the pollen may also be deposited a short distance above or below the hairy zone and sometimes also on the stigma.

The distribution maps were compiled using DIVA-GIS Version 5.2.0.2. They show the *Interim Biogeographic Regionalisation of Australia (IBRA) Version 6.1* regions (Department of the Environment, Water, Heritage and the Arts 2008).

Key to Western Australian members of all sections except *Arthrostigma*

Note that there are currently two difficult groups needing further study, the *P. crispata* R.Br. complex and the *P. squamata* R.Br. complex, whose members do not always key out reliably below. In these groups additional taxa may need to be recognised or some of the currently listed taxa may need to be synonymised.

1. Pollen presenter glabrous to moderately densely hairy; hairs (when present) minute or retrorse. Diaspore with a long to very reduced coma restricted to the base, not extending up the margins, terminally and often also laterally winged

 2. Tepals separating to the base and tending to fall individually

  3. Tepal limb either glabrous or with an obvious glabrous appendage; appendage subterminal, rod-like. Style glabrous except for the pollen presenter. Diaspore with a very reduced coma

   4. Juvenile foliage soft and fern-like; adult leaves villous when young, distinctive in appearance. Tepal limb hairy except for a long appendage. Diaspore markedly 3-lobed. (Cape Naturaliste to Hassell Beach.) .... **P. diversifolia**

   4: Leaves all similar, glabrous. Tepal limb glabrous, with no appendage. Diaspore entire or scarcely lobed. (Stirling Range to Cape Riche.) .... **P. carduacea**

  3: Tepal limb densely hairy, with no appendage but sometimes with a glabrous apical point which is often rather hidden by long hairs. Style hairy for at least half its length. Diaspore with a long coma

   5. Leaves more or less terete, 10–20 mm long, deeply divided, not toothed (Eneabba to Moore River.) .... **P. chrysantha**

   5: Leaves compressed, 15–90 mm long, simple or with 2 or 3 short lobes near apex, sometimes toothed

    6. Leaves 15–35 mm long, simple or with 2 or 3 short lobes at apex, plumose, glabrescent. (Gillingarra area.) .... **P. plumosa**

6: Leaves 45–90 mm long, simple but shortly and irregularly toothed in distal half, hirsute. (Alexander Morrison National Park to Coomaloo National Park.) .... **P. aculeata**

2: Tepals remaining joined along most of the length of the claw; swollen base (surrounding the diaspore) splitting when tepals fall together

7. Tepal apex hairy but with a long, glabrous, rod-like appendage. Pollen presenter with a very swollen base below a rod-like receptor. (Eneabba to near Donnelly River and Wagin.) .... **P. striata**

7: Tepal apex varied, if as above then pollen presenter fusiform

8. Pollen presenter more or less fusiform, with straight retrorse hairs

9. Leaves 30–200 mm long, glabrous or with scattered long hairs. Tepals with no glabrous appendage. Diaspore with a large wing extending laterally well beyond the seed; coma very reduced

10. Leaves compressed, glaucous. Tepals 10–21 mm long; appendage not obvious. (York area to Hopetoun.) .... **P. glauca**

10: Leaves terete, green. Tepals 20–25 mm long; appendage rod-like, very dark. (Moore River to Albany and Oldfield River.) .... **P. divaricata**

9: Leaves 15–35 mm long, usually with both long and much shorter hairs. Tepals with a rod-like, glabrous appendage at apex. Diaspore with a terminal wing not extending laterally beyond the sides of the seed and often poorly developed; coma long, its hairs covering one surface of diaspore

11. Tepals yellow, with spreading hairs; appendage clubbed, often extending well beyond the tepal apex. Occurring inland, mainly in lateritic areas. (Near Geraldton to Busselton area to Cape Riche area.) .... **P. serruriae**

11: Tepals pink or pink-mauve, with more antrorse hairs on the claw; appendage more acute and less conspicuous than in *P. serruriae*. Occurring on coastal limestone. (Near Geraldton to Augusta.) .... **P. axillaris**

8: Pollen presenter with its swelling ending fairly abruptly below a rod-like receptor, which is glabrous or has very short, recurved or patent hairs

12. Tepals 17–25 mm long, pink or pink-mauve. Pollen presenter with recurved hairs on summit of basal swelling. Diaspore coma with hairs mainly directed downwards or horizontal. (Darling Range from Wannamal to Oakley Dam.) .... **P. biloba**

12: Tepals 8–15 mm long, cream or yellow. Pollen presenter glabrous or with patent hairs on summit of swollen base and sometimes on base of receptor. Diaspore coma with hairs mostly directed upwards but with a few of them horizontal

13. Leaves (50–)65–160 mm long. Tepals 10–15 mm long. Pollen presenter base very concave at summit. (Moore River to Stirling Range to Oldfield River.) .... **P. heterophylla**

13: Leaves 15–65 mm long. Tepals 8–10 mm long. Pollen presenter base somewhat concave to tapered at summit

14. Leaves all or at least some of them simple, spathulate, 4–10 mm wide. (Stirling Range to Stokes Inlet.) .... **P. squamata** subsp. **Ravensthorpe**

14: Leaves broadly to very finely divided (but lower leaves sometimes simple and spathulate); ultimate divisions linear to obovate, 1–4 mm wide

15. Involucral bracts (or at least the inner ones) somewhat hairy on abaxial surface. Swelling of pollen presenter 0.4–0.7 mm diam., its apex more or less truncate or slightly convex (may be straight or oblique) and usually abruptly differentiated from receptor; receptor often minutely hairy. (Armadale to Israelite Bay.)................................**P. squamata** subsp. **northern**

15: Involucral bracts usually glabrous on abaxial surface. Swelling of pollen presenter 0.3–0.4 mm diam., its apex convex, usually tapering smoothly to receptor; receptor glabrous. (Busselton to Cape Riche.) .... **P. squamata** subsp. **squamata**

1: Pollen presenter sparsely to very densely hairy; hairs usually mostly straight and more or less patent (but tending to be retrorse in *P. macrostachya* and *P. shuttleworthiana*), rarely mostly ascending or long and markedly bent. Diaspore with a long coma extending up the margins, not winged

16. Plants non-viscid, with simple leaves and tepals hairy throughout. Pollen presenter with a swollen glabrous base, which is abruptly differentiated from the more or less cylindrical hairy top or (in one species) almost fusiform, the latter with clubbed hairs .... sect. **Arthrostylis** (see key in Rye & Hislop 2005)

16: Plants variously differing from the above combination of characters by having viscid bracts or tepals, toothed or divided leaves, or tepals glabrous at least at the apex. Pollen presenter more or less fusiform or narrowly ovoid to cylindrical, hairy on the swelling, the hairs never clubbed

17. Style hairy for about half or most of its length

18. Leaves compressed, with 2–5 ultimate divisions all in one plane. (Perenjori to Welbungin.).. **P. incurvata**

18: Leaves terete, simple or with widely spreading to divaricate divisions

19. Leaves simple. Flower heads axillary, few-flowered, sessile. (Burnerbinmah Station to Malangala Station.)..**P. vana**

19: Leaves usually divided, sometimes all simple. Flower heads terminal, many-flowered, sometimes pedunculate

20. Tepals 5–7 mm long. Cones less than 10 mm diam., with the scales and diaspores becoming separated. Occurring in the Eremaean. (Kalli Station area to Bimbijy Station.)..**P. pauciflora**

20: Tepals 8–15 mm long. Cones 15–20 mm diam., with overlapping scales and diaspores. Almost completely restricted to the South West Botanical Province

21. Flower heads and cones pedunculate. Tepals with appressed or closely antrorse hairs. Pollen presenter densely hairy throughout. (Cooloomia Nature Reserve to Mullewa.)...**P. semifurcata**

21: Flower heads and cones sessile. Tepals with somewhat spreading hairs. Pollen presenter with a glabrous or sparsely hairy base, the remainder hairy

22. Involucral bracts ovate or narrowly ovate, 4–8.5 mm long, 1.9–2.2 mm wide. Flower head ellipsoid or ovoid. Pollen presenter narrowly ovoid. (Kalbarri National Park to Morawa area.). ....**P. conifera** subsp. **conifera**

22: Involucral bracts ovate or broadly ovate, 5–7.5 mm long, 3.1–4.5 mm wide. Flower head ovoid or globose. Pollen presenter narrowly fusiform. (Coorow area.)............................ **P. conifera** subsp. **divaricata**

17: Style glabrous for most of its length but hairy on the pollen presenter and sometimes hairy just for a short distance above the diaspore

23. Leaves compressed, divided

24. Young stems with short, curled hairs. Flower heads more or less globular, with outer floral bracts and flowers often viscid. (Coorow to Moore River.) .... **P. biternata**

24: Young stems either with fine, straight hairs or glabrous. Flower heads elongate, not viscid

25. Stems remaining densely hairy below the flower heads. Leaves with a well defined midrib and main veins, the two primary lateral leaf lobes at least trifid. (Zuytdorp Cliffs to near Byford.)........ **P. macrostachya**

25: Stems (not including peduncles) glabrous below the flower heads. Leaves with multiple equal striations or smooth, the two primary lateral leaf lobes entire or bifid. (Kalbarri National Park (disjunct) and Perenjori to Moore River to Koorda area.)........ **P. shuttleworthiana**

23: Leaves thick, often more or less terete, simple or divided

26. Tepals glabrous

27. Leaves obtuse or acute but never pungent

28. Leaves simple, up to 15 mm long. (Lake Grace area to Stirling Range to Israelite Bay.)........ **P. phylicoides**

28: Leaves divided, over 30 mm long. (Ravensthorpe to Israelite Bay.)........ **P. fastigiata**

27: Leaves sharply pungent

29. Leaves simple to multi-branched, often trifid or with 3 main spreading divisions that are further divided. Involucral bracts few to numerous, pale- to dark-brown, mostly ovate or narrowly ovate, sometimes hairy outside. Pollen presenter 3–5 mm long, with hairs up to 0.3 mm long or glabrous. (Kalbarri National Park to Pinjarra area, near Kalgoorlie, Fitzgerald River area and near Lort River.)........ **P. seminuda**

29: Leaves multi-branched. Involucral bracts numerous, mostly dark-brown and broadly ovate or ovate, glabrous outside. Pollen presenter 2.5–3.5 mm long; hairs *c.* 0.2 mm long. (Unicup to Oldfield Estuary.)........ **P. crispata**

26: Tepals sparsely to densely hairy except for apical point

30. Leaves 20–200 mm long, if less than 30 mm long then much divided

31. Leaves simple. Tepals with a glabrous apical point that is long and obvious. (Bodallin and Bullabulling to Lake King.)........ **P. stricta**

31: Leaves divided. Tepals with a glabrous apical point that is short or long, and often not obvious

32. Involucral bracts glabrous, viscid. Tepals sparsely or moderately densely hairy, viscid. (Dongara area to Dongolocking.)........ **P. drummondii**

32: Involucral bracts silky-hairy inside and sometimes also with hairs outside, not viscid. Tepals densely hairy, not viscid

33. Flower heads with exceptionally large involucral bracts (often over 20 mm long), subtended by leaves 90–200 mm long. Tepals 30–40 mm long. (Boorabbin to Pingelly to Lake King.)........ **P. circinata**

33: Flower heads with normal-sized involucral bracts, subtended by leaves 30–85 mm long. Tepals 11–15 mm long. (Regans Ford to Walpole and to Fitzgerald River National Park.)..**P. rigida**

30: Leaves 5–22 mm long, if *c.* 20 mm long then divided into 3–5 short lobes

34. Leaves divided from near the base into usually 7 branches. (Watheroo area.)...... **P. septemfida**

34: Leaves simple or distally divided into 3–5 short lobes

35. Leaves all, or at least a few of them, distally divided into 3–5 lobes

36. Leaves with short curly hairs, minutely scabrous, 8–16 mm long. (Tammin to Quairading to Bruce Rock.) .... **P. misturata**

36: Leaves glabrous or only the younger ones hairy, smooth or very minutely scabrous, 10–21 mm long

37. Flower heads rather few-flowered, not viscid. Pollen presenter 2–3 mm long. (Coorow to Wongan Hills.) .... **P. trifurcata**

37: Flower heads many-flowered, with viscid floral bracts. Pollen presenter 3–4 mm long. (Lake Grace area.) .... **P. ericifolia × seminuda**

35: Leaves all simple

38. Young stems and leaves (on new shoots at least) with very curly hairs but no straight to curved hairs

39. Tepals sparsely hairy. (Involucral bracts usually very viscid.) (Southern Cross to Bullabulling to Lake King area.)..**P. merrallii**

39: Tepals moderately densely or densely hairy

40. Leaves glabrous or very sparsely hairy and rapidly becoming glabrous. Involucral bracts often viscid. (Bullabulling area to Peak Charles area.) ....**P. arcuata**

40: Leaves hairy at first and tending to retain the curly hairs for some time. Involucral bracts not viscid

41. Leaves usually antrorse or appressed, 5–9 mm long, blunt. (Dalwallinu to near Koorda and Dowerin.)... **P. wonganensis**

41: Leaves all spreading, 8–16 mm long, pungent. (Tammin to Quairading to Bruce Rock.) .... **P. misturata**

38: Young stems and leaves with or without curly hairs but always with curved to straight hairs at least on new shoots

42. Involucral bracts viscid and coherent into a cup-like structure that is persistent around the cone. (Corrigin to Fitzgerald River National Park.) ....**P. cyathiforma**

42: Involucral bracts free from one another and often deciduous before fruit matures

43. Involucral bracts numerous, not obviously viscid, dark with broad grey margins, hairy. Pollen presenter 3.5–6 mm long. (Brookton area to Katanning.) .... **P. imbricata**

43: Involucral bracts few to numerous, often very viscid, uniformly coloured, glabrous or hairy. Pollen presenter 2.75–4.5 mm long

44. Leaf apex with a viscid globule. Involucral bracts broad, shortly pointed, glabrous. Occurring from Piawaning to Cape Riche

  45. Young stems with straight or curved hairs. Leaves usually patent, usually smooth and glabrous. (Harrismith to Ravensthorpe and Cape Riche.) .... **P. ericifolia** subsp. **ericifolia**

  45: Young stems with curled hairs. Leaves often antrorse, usually with hairs or tubercular remnants of hairs. (Piawaning to Northam and Kellerberrin.) .... **P. ericifolia** subsp. **subpubescens**

44: Leaf apex with a non-viscid point. Involucral bracts narrow and tapering usually into a long point, at least the lower ones slightly to obviously hairy. Occurring from Kalbarri to the Regans Ford area

  46. Involucral bracts 5–9.5 mm long, usually not viscid. Tepals with a dense indumentum always extending onto lower part of apical point (i.e. above the top of the anther) and partly to completely obscuring it, the longest hairs 1.5–2.5 mm long. (Wicherina to Warradarge.) .... **P. scabriuscula**

  46: Involucral bracts 2–5(–7) mm long, viscid. Tepals with a sparse to dense indumentum, often not extending above level of top of anther, with the apical point usually obvious, the longest hairs up to 1.5 mm long

    47. Tepals with a moderately dense to dense indumentum, not viscid. Occurring north of Geraldton. (Kalbarri to Hutt River.) .... **P. foremanii**

    47: Tepals with a sparse to moderately dense indumentum, viscid at apex. Occurring south of Geraldton

      48. Leaves 3–5.7(–7.5) mm long, (0.5–)0.7–0.8 mm wide, often densely scabrous, distally erect (but apical point sometimes recurved). Tepal hairs all straight to somewhat wavy. Cone scales 4–8 mm wide. (Near Morawa to Marchagee and Pithara.) .... **P. globifera**

      48: Leaves 6–9(–11) mm long, 0.4–0.7 mm wide, smooth or sparsely scabrous, distally recurved. Lower tepal hairs strongly wavy. Cone scales 2–4 mm wide. (Warradarge area to Wannamal.) .... **P. recurva**

Taxonomic descriptions

This section of the paper gives full descriptions of the new or reinstated taxa and other relevant taxa except for the presumed hybrid, which is treated in a separate section. Notes on other taxa are given in a final section.

Petrophile axillaris Meisn., *Hooker's J. Bot. Kew Gard. Misc.* 7: 68–69 (1855). *Type*: between Moore and Murchison Rivers [Western Australia], 1850–1851, *J. Drummond* coll. 6, no. 166 (*syn*: K (2 sheets) *n.v.*, MEL 1534425).

Illustration. D.B.Foreman, *Fl. Australia* 16: fig. 51 (1995).

Shrubs 0.4–1.5 m high, erect or ± sprawling, single-stemmed and fire-sensitive. *Branchlets* ribbed, brown or grey, with a moderately dense indumentum of patent hairs that are variable in length, overtopped by a much sparser layer of longer hairs to *c.* 4 mm long. *Leaves* spreading, usually rather irregularly bipinnatisect, sometimes tripinnatisect, 17–30 mm long, 16–33 mm wide, with scattered hairs that are mostly antrorse and 1–2 mm long; lobes narrow, slightly compressed, with a pungent point 0.6–1.2 mm long. *Flower heads* mostly axillary, often pedunculate, globose, 15–25 mm long, 17–28 mm diam.; peduncle 2.3–3.5 mm long. *Involucral bracts* erect or spreading, elliptic to ovate, 2.7–3.8 mm long, 1.3–2.0 mm wide, acute or acuminate, yellow to brown, becoming pink at the apex; outer surface with up to 5 ribs, glabrous or with a dense tuft of hairs 0.2–0.4 mm long at the base; inner surface glabrous. *Floral bracts* broadly ovate, 4.9–6.2 mm long, 2.6–4.4 mm wide, acute or acuminate, yellow-green to brown; outer surface with appressed white hairs in the basal half to two thirds, apex glabrous; inner surface glabrous. *Tepals* 11–17(–22) mm long, densely hairy; claw pink, with a variable indumentum of antrorse hairs 0.5–1.1 mm long, base glabrous; limb 2.8–3.5 mm long, with antrorse hairs 0.8–1.6 mm long and a glabrous, narrowly cylindrical, tapering apical appendage 0.3–0.7 mm long, which is often somewhat obscured by the hairs. *Anthers* 1.6–1.9 mm long. *Pistil* 12–18 mm long, with shallowly antrorse to more or less patent hairs 0.2–0.3 mm long reaching almost to the base of pollen presenter. *Pollen presenter* 3.2–4.5 mm long; swollen part narrowly ovoid to fusiform, glabrous at base, with scattered, straight or slightly curved, retrorse hairs *c.* 0.1 mm long over most of its length; glabrous apical part 0.6–1.0 mm long. *Cones* globose to ovoid, 9–20 mm long, 8–17 mm diam.; scales broadly ovate. *Diaspores* ovate in outline, 4.2–5.2 mm long, 2.3–3.1 mm wide, including a narrowly triangular, readily detached, terminal wing, upon which the style remains often form an apical beak; abaxial surface glabrous over most of surface, with scattered, appressed, white hairs less than 0.1 mm long towards the apex; adaxial surface with a moderately dense indumentum of white or purple, appressed hairs less than 0.1 mm long, overtopped towards the base by the layer of much longer, white or golden hairs up to 5 mm long, that comprise part of the basal coma. (Figure 1A)

Selected specimens examined. WESTERN AUSTRALIA: Arrowsmith River area, S of Dongara, 15 Sep. 1968, *A.C. Burns* 60 (PERTH); Yalgorup National Park, 3 km N of Lake Preston causeway, 9 Nov. 1978, *J. Dodd s.n.* (PERTH); 5 km W of Lake Indoon, 30 July 1977, *E.A. Griffin* 933 (PERTH); N side of Cervantes road, 16 km E of Cervantes, 8 Oct. 1993, *P.C. Jobson* 2268 (PERTH); Mindarie, 27 km N of Perth, 24 Sep. 1988, *G.J. Keighery* 11421 (PERTH); 4 km SE of Cape Freycinet [S of Margaret River], 24 Sep. 1990, *G.J. Keighery* 11605 (PERTH); Quadrat WMA77, N boundary, South Mimegarra Nature Reserve, C 30618, Shire of Gingin, 7 Oct. 1999, *M.A. Langley & P.M. Smith* MAL 1937 (PERTH); Star Swamp Bushland Reserve, North Beach, 13 Sep. 1987, *J.P. Pigott s.n.* (PERTH); 1 km N of Kwinana turnoff on road to Mandurah, 7 Nov. 1985, *J.M. Powell* 2094 (NSW, PERTH); 8 km from Two Rocks along Breakwater Drive, turn right on Tringa Rd a further 1.6 km, 25 Sep. 2002, *K. Richardson* KCR118 (PERTH); Bob's Hollow, track 1 km from coast, 26 Oct. 2000, *J. Scott* 275 (PERTH).

Distribution and habitat. Occurs in the South-West Botanical Province in yellow or grey-brown sand in limestone areas along the west coast from near Geraldton south to Yalgorup National Park, with an isolated occurrence further south in Leeuwin–Naturaliste National Park (Figure 2A). The disjunction between this southern occurrence of this species and the remainder of its range is about 130 km and corresponds in part with a break in the limestone habitats along the coast.

Phenology. Flowers mainly September to November.

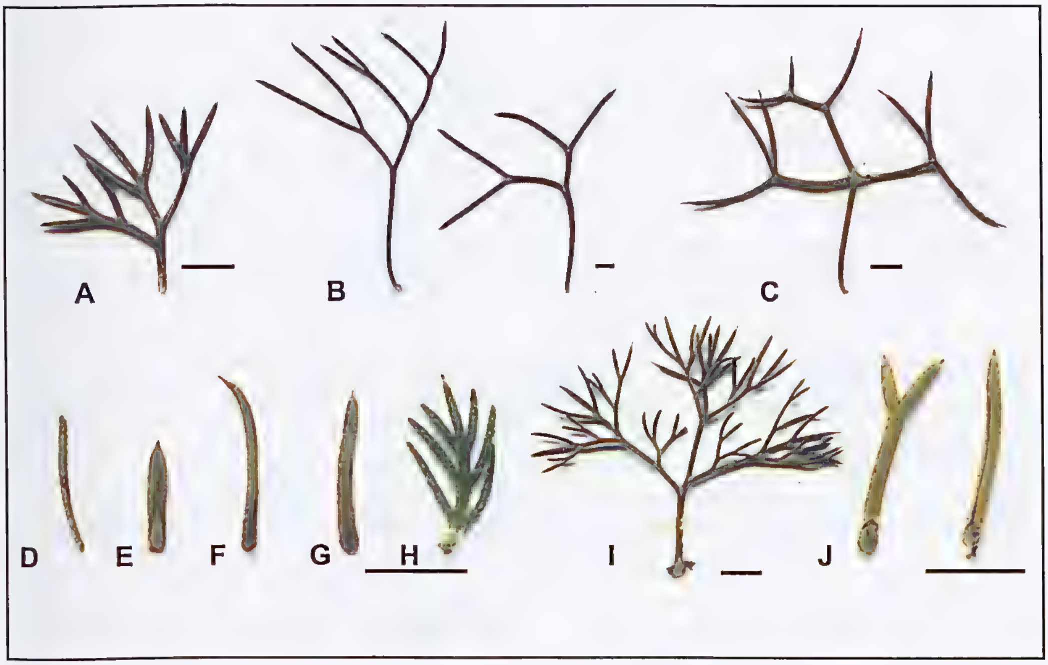

Figure 1. Leaf outlines. A – *P. axillaris* PERTH 04244788; B – *P. conifera* subsp. *conifera* PERTH 01865897, C – *P. conifera* subsp. *divaricata* PERTH 04647378, D – *P. formanii* PERTH 05039207, E – *P. globifera* PERTH 05056578, F – *P. recurva* PERTH 03440915, G – *P. scabriuscula* PERTH 04696182, H – *P. septemfida* PERTH 07978014, I – *P. serruriae* PERTH 04655257, J – *P. trifurcata* PERTH 03458903. Scale bars = 5 mm.

Conservation status. A relatively common, widespread species.

Lectotypification. A lectotype should probably be chosen from one of the two sheets at K, as Meissner (1855) based most of his new taxa on the material he examined while in England. K type material was examined by Alex George, who confirmed that it was of the same taxon as the MEL sheet examined by us.

Affinities. Reinstatement of *Petrophile axillaris* addresses the problem noted by George (1998) regarding the variability shown by *P. serruriae* R.Br. *s. lat.* Although *P. axillaris* is very closely related to *P. serruriae*, it differs in having pink, rather than yellow tepals, a more appressed indumentum on the claw, and in having an apical appendage which tapers towards the apex as opposed to the clavate appendage of the latter species. It also has a more compact growth habit than *P. serruriae* and has a quite distinct habitat and distribution, being confined to coastal limestone.

Notes. The pollen is deposited on the hairy part of the pollen presenter and also up to the level of the stigma. This raises the possibility that autogamous self-fertilisation may sometimes occur in this species.

Only two PERTH collections have been made from the isolated southern area of occurrence of the species in Leeuwin–Naturaliste National Park. These specimens have somewhat longer and more spreading hairs than normal on the tepals and their floral parts are at the lower end of the size range

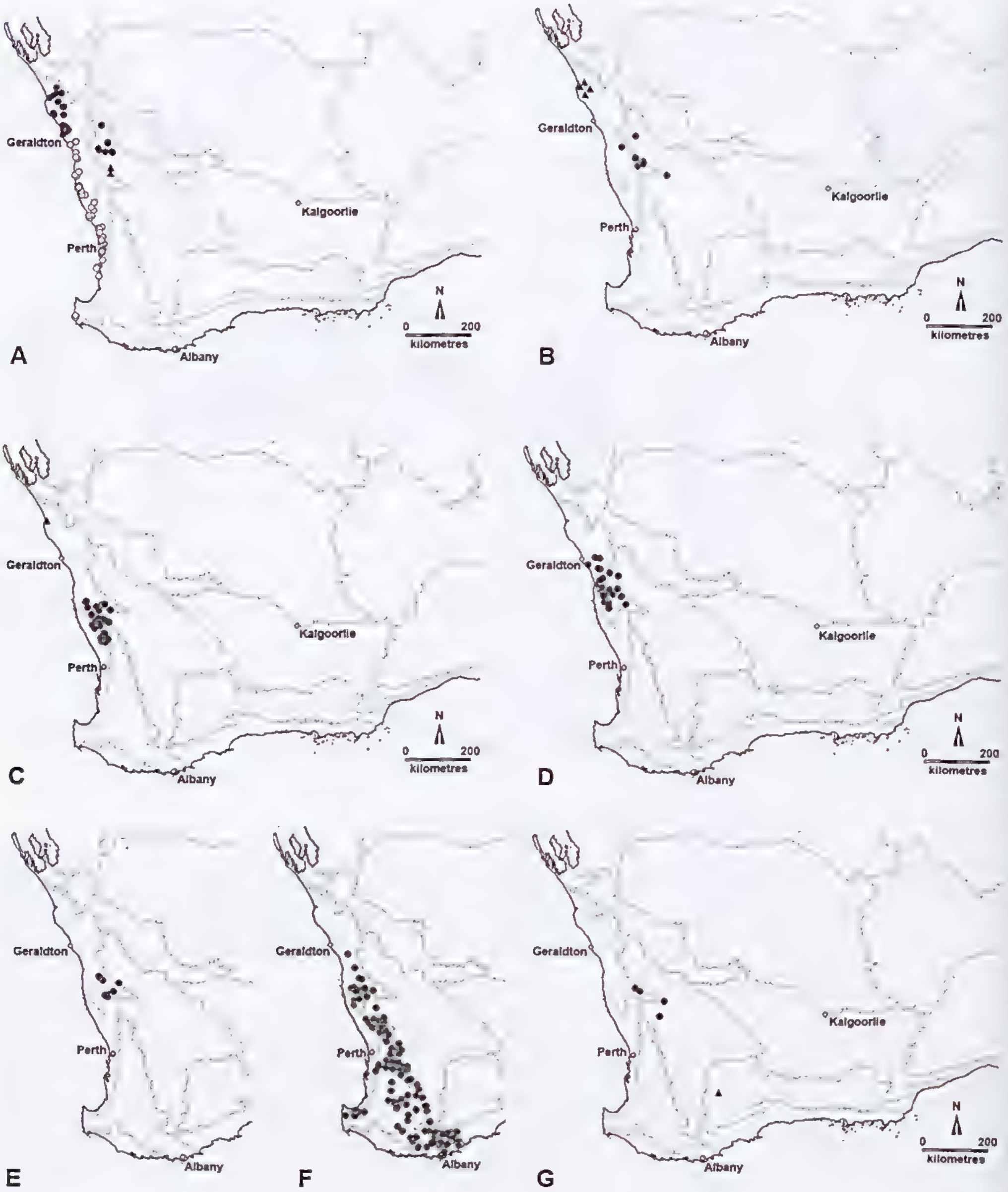

Figure 2. Distribution maps for the new taxa. A – *Petrophile axillaris* (○), *P. conifera* subsp. *conifera* (●) and *P. conifera* subsp. *divaricata* (▲); B – *P. foremanii* (▲) and *P. globifera* (○); C – *P. recurva*; D – *P. scabriuscula*; E – *P. septemfida*; F – *P. serruriae*; G – *P. trifurcata* (●) and *P. ericifolia* × *seminuda* (▲)

for the species as a whole. Those differences are not considered sufficient to warrant taxonomic recognition.

Petrophile conifera Meisn., *Hooker's J. Kew Gard. Misc.* 7: 67 (1855). *Type*: Murchison River, Western Australia, 1850–1851, *J. Drummond* coll. 6, n. 167 (*syn*: MEL 1534408).

Affinities. Closely related to *Petrophile incurvata* W.Fitzg. and *P. semifurcata* F.Muell. ex Benth., differing as discussed under those species. Note also that *P. conifera* overlaps greatly in distribution with *P. semifurcata* without losing its integrity and that its very distinctive subspecies *divaricata* Hislop & K.A.Sheph. occurs within the range of *P. incurvata*.

Notes. During the 1940s, Gardner (unpub.) considered that there were insufficient differences between *Petrophile conifera* and *P. semifurcata* to retain them as separate species. He also considered *P. incurvata* to be conspecific with *P. conifera*, and planned to reduce both taxa to varieties. In all, he recognised four varieties under *P. conifera* as he also intended to name a new taxon as *P. conifera* var. *divaricata* C.A.Gardner ms. Like Foreman (1995), we consider *P. incurvata* and *P. semifurcata* to be good species, readily distinguished from *P. conifera*. However, the new taxon is more similar in morphology to *P. conifera* and is described here as a new subspecies.

a. **Petrophile conifera** Meisn. subsp. **conifera**

Shrubs 0.4–2 m high. *Branchlets* smooth or slightly ribbed, grey-brown, with a dense, mixed indumentum of ± straight or crinkled longer hairs up to 0.3 mm long and a layer of shorter, crisped hairs, at length glabrescent. *Leaves* rather variable, usually pinnatisect, and then often with further division of the basal lobes, but sometimes bipartite or tripartite, with or without secondary division, 30–100 mm long (including 'petiole' 20–48 mm long), 30–55 mm wide, terete, glabrous, usually recurved along the longitudinal axis, with (2–)5–9 ultimate lobes, each 7–32 mm long and terminating in a pungent point 0.5–1.5 mm long. *Flower heads* terminal, sessile, or occasionally with a very short peduncle, ovoid or ellipsoid, 22–32 mm long, 15–21 mm diam. *Involucral bracts* erect, narrowly ovate or ovate, 4.0–8.5 mm long, 1.9–2.2 mm wide, with apex acuminate, the margins densely ciliate with antrorse hairs to *c.* 1 mm long; outer surface with moderately dense, appressed hairs 0.1–0.25 mm long; inner surface with a dense indumentum of rather wavy, antrorse hairs 0.5–1 mm long. *Floral bracts* ovate, 4.5–8.1 mm long, 2.2–3.8 mm wide, acuminate, brown, margins ciliate; outer surface with a dense indumentum of antrorse hairs throughout, the longest of these (to 1.8 mm long) in the distal third; inner surface glabrous. *Tepals* 8–13 mm long, densely hairy; claw creamy yellow, with antrorse hairs 0.5–0.8 mm long, glabrous at base; limb 3.5–5 mm long, with straight hairs 0.5–1 mm long. *Anthers* 2.1–3.5 mm long. *Pistil* 12–15 mm long, with scattered simple hairs 0.3–0.4 mm long on the style. *Pollen presenter* 3.1–4.7 mm long; swelling narrowly ovoid, with a moderately dense indumentum of patent hairs 0.1–0.25 mm long over most of its length, but with a glabrous base; unswollen apical part 0.6–0.8 mm long. *Cones* ovoid or narrowly ovoid, 18–27 mm long, 12–16 mm diam.; scales broadly ovate. *Diaspores* ovate or broadly ovate in outline, 5.1–6.2 mm long including the apical beak formed by the enlarged base of the style and 3.0–4.4 mm long excluding the beak, 2.7–3.2 mm wide, with an erect coma of hairs 2–3 mm long on the lower margins and base; abaxial surface with moderately dense, white indumentum of antrorse-appressed hairs (0.3–0.7 mm long) throughout; adaxial surface with scattered long hairs of the same type that form the coma and densely covered by very short, dark-purple hairs, except at the apex where there is a zone of short, white hairs. (Figure 1B)

Selected specimens examined. WESTERN AUSTRALIA: Loop Rd, Kalbarri, 3 Aug. 1987, *D.R. & B. Bellairs* 1747 (PERTH); G. Burrows, White Peaks, 24 July 1999, *J.L. Checker* 1 (PERTH); 5 km S of Binnu on North West Coastal Highway, 9 Sep. 1997, *G. Flowers* 237 *& S. Donaldson* (PERTH); 28 km S of Tardun on Great Northern Highway, 11 Sep. 1984, *D.B. Foreman* 648 (PERTH); Koolanooka, 19 Sep. 1931, *C.A. Gardner* 2679 (PERTH); 17 km W of Morawa, 19 Aug. 1997, *F. Keast* M1A 005 (PERTH); Eurardy Station, *c.* 43 km N of Kalbarri turn-off on the North West Coastal Highway, 29 Aug. 2003, *Wildflower Society of Western Australia* EURA 231 (PERTH).

Distribution and habitat. Extends from Eurardy Station and Kalbarri National Park south to Spalding Park (on the Chapman River, Geraldton), and south-east to the Morawa area, in the South-West Botanical Province (Figure 2A). Occurs in a variety of sandplain and rocky locations including lateritic ridges, often with *Allocasuarina campestris*.

Phenology. Flowers July to September.

Conservation status. Not considered to be at risk at present.

Notes. This subspecies is much more widespread and variable than *Petrophile conifera* subsp. *divaricata*, and its leaves are more erectly branched. There is a disjunction in its currently known range between the near-coastal populations extending from Eurardy Station south to the Moresby Range and the inland populations extending from near Pindar south to the Morawa area. Leaves of the inland specimens invariably have the petiole curved towards the apex of the branch whereas those of the near-coastal specimens tend to be variable in orientation and more spreading on average, often with some of the petioles somewhat recurved.

b. **Petrophile conifera** subsp. **divaricata** Hislop & K.A.Sheph., *subsp. nov.*

A subspecie *conifera* foliis magis divaricatis, basis integra breviore, bracteis involucralibus brevioribus et latioribus, bracteis strobilibus latioribus differt.

Typus: Coorow, Western Australia, 14 September 1932, *W.E. Blackall* 2595 (*holo*: PERTH 01865773; *iso*: PERTH 03440044).

Petrophile conifera var. *divaricata* C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Petrophile sp. Coorow (W.E. Blackall 2595), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed March 2009].

Shrubs to 1 m high. *Branchlets* smooth, grey-brown, with a dense indumentum of hairs 0.2–0.4 mm long, glabrescent. *Leaves* divaricately tripartite, the primary lobes further divided into 2 or 3 divaricate lobes, (20–)35–50 mm long (including a 'petiole' 12–24 mm long), 30–55 mm wide, rigid, terete, glabrous, with 6–9 ultimate lobes each 7–24 mm long and terminating in a pungent point 0.5–1.6 mm long. *Flower heads* terminal, sessile, ovoid to ellipsoid, 18–22 mm long, 18–22 mm diam. *Involucral bracts* erect, ovate or broadly ovate, 2.5–6.5 mm long, 2.5–4.1 mm wide, acuminate, margins densely ciliate with antrorse hairs to *c.* 1.5 mm long; outer surface with a moderately dense indumentum of straight or wavy, appressed hairs 0.2–0.3 mm long; inner surface with a dense indumentum of straight or curly hairs 0.4–1.0 mm long. *Floral bracts* ovate, 5–8.2 mm long, 1.5–3.5 mm wide, acuminate, brown, the margins densely ciliate; outer surface with a dense indumentum of appressed hairs 0.1–0.25 mm long; inner surface glabrous. *Tepals* 11–14 mm long, densely hairy; claw creamy yellow, with straight or wavy hairs 0.4–1.0 mm long, glabrous at base; limb 3–4 mm long, with erect hairs 0.5–1.2 mm long. *Anthers* 2.5–3.4 mm long. *Pistil* 14–15 mm long, with scattered simple hairs 0.2–0.5 mm long on the style. *Pollen presenter* 4.1–5.1 mm long; swelling narrowly fusiform, with a moderately dense indumentum of patent hairs 0.15–0.3 mm long; unswollen apical part 0.4–0.6 mm long. *Cones* ovoid, 17–20 mm long, 14–16 mm diam.; scales broadly ovate. *Diaspores* ovate in outline, 5.0–6.8 mm long including the apical beak formed by the enlarged base of the style and 3.0–4.5 mm long excluding the beak, 2.9–3.1 mm wide; indumentum as for the typical subspecies. (Figure 1C)

Other specimens examined. WESTERN AUSTRALIA: [precise localities withheld for conservation reasons], 3 Oct. 2008, *J. Borger* AD 310-4 (PERTH); 9 Sep. 1995, *F. Falconer* 44 (PERTH).

Distribution and habitat. Occurs near Coorow in the South-West Botanical Province (Figure 2A). Recorded on an undulating rocky slope with red clay over granite, growing with Sandalwood, *Allocasuarina campestris* and *Dryandra*.

Phenology. Flowers recorded in September.

Conservation status. Listed as Priority One under Department of Environment and Conservation (DEC) Conservation Codes for the Western Australian Flora under the name *Petrophile* sp. Coorow (W.E. Blackall 2595) (Smith 2010). This subspecies is currently known from two localities on private land. Only a vague locality was recorded for the type specimen collected in 1932.

Etymology. From the Latin *divaricatus* (widely spreading), referring to the divaricately branched leaves.

Notes. This taxon occurs at least 50 km south of the range of *Petrophile conifera* subsp. *conifera*. It differs from the typical subspecies in having shorter petioles (12–24 mm vs. 20–48 mm long), broader involucral bracts (2.5–4.1 mm vs. 0.9–2.2 mm) that also tend to be shorter, and a differently shaped pollen presenter (narrowly fusiform vs. narrowly ovoid). It has more or less patent leaves with strongly divaricate branching, whereas the inland variant of *P. conifera* from the Pindar to Morawa area has more erect leaves and more erect branching of each leaf.

Petrophile foremanii Rye & Hislop, *sp. nov.*

A *Petrophile scabriuscula* Meisn. bracteis involucralibus plerumque brevioribus et plus viscidibus, tepala indumento brevioribus, et distributio septentrionalibus differt.

Typus: Kalbarri National Park, 6 km north-east of Kalbarri on the Ajana–Kalbarri road, Western Australia, 9 September 1984, *D.B. Foreman* 621 (*holo*: PERTH 05222028; *iso*: CANB *n.v.*, MEL 2044008 *n.v.*).

Petrophile sp. Kalbarri (D.B. Foreman 621), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed March 2009].

Shrubs 0.6–2 m high. *Branchlets* smooth, yellow-grey to brown, with a dense indumentum of tightly coiled hairs and scattered straighter hairs 0.4–0.7 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight or incurved over most of their length but with the apex sometimes recurved, 8–11 mm long, 0.6–0.8 mm wide, scabridulous, with scattered, straight, white hairs mostly 0.5–1 mm long when young, becoming glabrous except for a row of hairs protruding along adaxial surface; apex acute, innocuous to coarsely pungent, the point 0.3–0.5 mm long. *Flower heads* terminating branchlets, sessile, depressed-ellipsoid to globose, usually 10–20 mm diam. *Involucral bracts* erect, narrowly ovate to subulate, (3.7–)4–6(–7) mm long, 0.8–1.3 mm wide, viscid, with an acuminate apex, with margins sparsely to densely ciliate, the longest cilia 0.6–1.3 mm long; outer surface sparsely hairy at the base and/or in the central region, glabrous at apex; inner surface glabrous at base, sometimes hairy distally. *Floral bracts* narrowly ovate, 3.5–5.5 mm long, mostly 0.8–1.3 mm wide (outermost ones often much broader), acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1.5–2 mm long, glabrous at apex; inner surface glabrous. *Tepals* 10–15 mm long, with a moderately dense or dense indumentum of straight hairs, the longest hairs 0.6–1.5 mm long; claw creamy yellow, glabrous at base; limb 3–4.5 mm long, not viscid, often with the indumentum extending above the top of the anther but with extreme apex of tepal glabrous, sometimes entirely glabrous above the top of the anther but with the long hairs attached below this level often extending to cover the glabrous apex. *Anthers* 2.3–2.5 mm long. *Pistil* 11–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.2–3.7 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.5–1 mm, with patent hairs up to 0.1 mm long over most of its length; unswollen apical part 0.7–1 mm long. *Cones* ellipsoid to globose, 8–14 mm long, 8–12 mm diam.; scales broadly ovate to circular, 5–7 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* more or less elliptic to broadly obovate in outline, 3–4.3 mm long including the apical beak formed by the enlarged base of the style and 2.5–3 mm long excluding the beak, 1.9–2.6 mm wide, with a coma of straight, white, hairs 3–5 mm long and purplish black hairs up to 0.3 mm long on the margins and base; abaxial surface flat, with minute, appressed, white hairs or glabrous; adaxial surface deeply convex, with a longitudinal division down the centre, glabrous or with some appressed, white hairs 0.1–0.7 mm long and often partially covered by minute, spreading, purple-black hairs. (Figure 1D)

Selected specimens examined. WESTERN AUSTRALIA: southern boundary of Kalbarri National Park on S side of Vermin Proof Fence, 21 Oct. 1974, *J.S. Beard* 7129 (PERTH); Kalbarri National Park, Loop Rd within 0.5–2.8 km of main road, vicinity of first car park, 11 Oct. 1986, *R.S. Cowan* A271 (PERTH); N from junction of Kalbarri–Ajana road, 12 Sep. 2001, *R. Davis* 10033 (PERTH); corner of Yerina Springs Rd and Ogilvie Rd West, 9 Sep. 1984, *D.B. Foreman* 613 (PERTH).

Distribution and habitat. Occurs in the Kalbarri area of the South-West Botanical Province, extending from near the lower Murchison River south to near Hutt River (Figure 2B). Occurs in white or yellow sand, in shrublands sometimes dominated by *Banksia* or *Acacia*.

Phenology. Flowers May to October.

Conservation status. The known range of this taxon is less than 50 km but nearly all of its locations are within a large national park.

Etymology. Named in honour of Don Foreman, who made a significant contribution to the taxonomy of *Petrophile* but unfortunately was unable to complete his studies of the genus. He named 14 new species of *Petrophile* (Foreman 1990, 1995) and his collections have been used for the types of this new taxon and *P. globifera* Rye & K.A.Sheph.

Affinities. This taxon is one of four named taxa belonging to the *Petrophile scabriuscula* Meisn. species complex, which extends from Kalbarri National Park south to near Wannamal. The other three taxa occur south of its range, with the closest one, *P. scabriuscula*, separated by about 75 km. *Petrophile scabriuscula* differs in its longer involucral bracts, which are usually not viscid, and in always having densely hairy tepals, with the indumentum of the outer surface extending above the level of the top of the anther (inserted on the inner surface). See also the notes under *P. globifera* and *P. recurva* Foreman below.

Notes. In any species complex, it is difficult to determine the most appropriate taxonomic status for its members. As the new taxon described above is geographically separated from the remainder of the *Petrophile scabriuscula* complex, it is unlikely to be confused with other taxa. It does not show very large morphological differences from *P. scabriuscula* and possibly should be regarded as a subspecies of that taxon. However, it also shows some similarities to the other members of the complex, for example in having viscid involucral bracts, and there does not seem to be a good case to choose a lower taxonomic status for it than for *P. globifera* and *P. recurva*.

Note that the length of the apical point on the leaves is sometimes apparently extended on the dorsal surface, in both this taxon and *P. globifera*, by a broad brown patch but the measurements of the point exclude that region.

Petrophile globifera Rye & K.A.Sheph., *sp. nov.*

Petrophile scabriusculae Meisn. affinis sed bracteis involucralibus brevioribus, inflorescentiis plerumque plus viscidibus, pollinis praebitor plerumque longiore et distributio mediterranissimis differt.

Typus: Marchagee Track, Western Australia [precise locality withheld for conservation reasons], 1 September 1984, *D.B. Foreman* 490 (*holo:* PERTH 05222427; *iso:* AD *n.v.*, CANB *n.v.*, MEL *n.v.*).

Petrophile sp. Pithara (P. Armstrong s.n. PERTH 06592090), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed March 2009].

Shrubs to 0.7–1.2 m high. *Branchlets* smooth or ribbed, yellow-grey or reddish brown, with a dense indumentum of wavy to tightly coiled hairs 0.1–0.3 mm long, at length glabrescent. *Leaves* erect, moderately crowded, simple, sub-terete, straight or very slightly curved towards the apex, 3–5.7(–7.5) mm long, (0.5–)0.7–0.8 mm wide, scabridulous, glabrous or with scattered, straight or wavy, white hairs 0.2–0.7 mm long; apex acute, innocuous to coarsely pungent, the point 0.2–0.4 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, depressed-ellipsoid to globose, 10–18 mm diam. *Involucral bracts* erect, narrowly ovate, 2.0–4.2 mm long, 0.7–1.5 mm wide, with an acuminate apex 0.7–1.2(–2) mm long, viscid, glabrous throughout or margins with scattered hairs 0.3–0.5 mm long. *Floral bracts* narrowly ovate to broadly subulate, 3.8–5.3 mm long, 1.3–2.6 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy, cream to white hairs 0.8–2 mm long, but glabrous towards the apex; inner surface glabrous or with a few hairs at the base. *Tepals* (7.5–)10–15 mm long, with a sparse or moderately dense indumentum of straight or nearly straight hairs, the longest hairs 1–1.5 mm long; claw cream to pale-yellow, glabrous at base; limb 3.5–4 mm long, often viscid, usually glabrous above the top of the anther, with the long hairs attached below this level rarely extending beyond the glabrous apex. *Anthers* 1.5–2.5 mm long. *Pistil*

9–14 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.4–5.1 mm long; swelling fusiform, glabrous in basal 0.4–0.8 mm, with a moderately dense indumentum of patent hairs 0.1–0.2 mm over most of its length; unswollen apical part 0.4–0.6 mm long. *Cones* ellipsoid to globose, 9–12 mm long, 10–14 mm diam.; scales elliptic to very broadly ovate, 4–8 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* ovate to elliptic in outline, 3.3–4 mm long including the apical beak formed by the enlarged base of the style and 2.5–3.3 mm long excluding the beak, 1.6–3 mm wide, with an erect coma of cream to brown hairs 3–4.5 mm long on the margins and base; adaxial and abaxial surfaces with scattered, short, stiff, purple-brown hairs 0.1–0.15 mm long at the apex, the remainder glabrous. (Figure 1E)

Selected specimens examined. WESTERN AUSTRALIA: [localities withheld] 15 Sep. 1993, *P. Armstrong s.n.* (PERTH); 8 Oct. 1992, *A. Carr* 129 (PERTH); W of Coorow, 7 Oct. 1992, *E.A. Griffin* 7137 (PERTH); 28 Apr. 1997, *F. Keast* M2B 112 (PERTH); S of Coorow, 18 Aug. 1953, *R. Melville* 1423 *& J. Calaby* (PERTH); Irwin District, 29 Sep. 1979, *J. Taylor* 976, *M.D. Crisp & R. Jackson* (PERTH).

Distribution and habitat. Extends from near Morawa south to the Marchagee area and south-east to near Pithara in the South-West Botanical Province (Figure 2B). Occurs in sand, with the dominant species varied but including mallees, *Grevillea* species, *Actinostrobus arenarius* and *Allocasuarina campestris*.

Phenology. Flowers August to October.

Conservation status. Listed by Smith (2010) as Priority Three (DEC Conservation Codes for the Western Australian Flora) under the name *Petrophile* sp. Pithara (P. Armstrong s.n. PERTH 06592090). This taxon has been recorded from about eight localities over a distance of about 150 km. Although not specifically recorded from any national parks or other reserves, it is known from the vicinity of Watheroo National Park.

Etymology. From the Latin *globus* (sphere) and *fero* (to bear), referring to the flower heads, whose spherical shape is particularly obvious in this species because they are borne on stems with short, appressed leaves.

Affinities. This taxon is one of four named taxa belonging to the *Petrophile scabriuscula* species complex. It has the most easterly distribution within the complex, although it overlaps in range with both *P. scabriuscula* and *P. recurva*, especially the former.

Petrophile globifera differs from the three other members of the complex in its usually shorter and broader leaves, its shorter involucral bracts and its usually longer pollen presenter. It can also be distinguished from *P. foremanii* by the sparser indumentum on its stems, from *P. recurva* by its straighter leaf apex and broader cone scales, and from *P. scabriuscula* by the sparser indumentum on its tepals.

Notes. Separation of the four members of the *Petrophile scabriuscula* complex is clear-cut for most specimens but there are a few that are difficult to assign. These four taxa appear to warrant formal recognition as distinct entities but whether all should be treated as species or some as subspecies is not certain. *Petrophile globifera* is described here as a species because it appears to be as distinctive as the two previously named taxa, *P. scabriuscula* and *P. recurva.*

Petrophile recurva Foreman, *Fl. Australia* 16: 477 (1995). *Type*: *c.* 17 miles [*c.* 27 km] from Moora towards Jurien Bay, Western Australia, 23 September 1962, *M.E. Phillips s.n.* (*holo*: CBG 005328 *n.v.*; *iso*: MEL 727037, NSW *n.v.*)

Illustration. D.B.Foreman, *Fl. Australia* 16: fig. 89 (1995).

Shrubs to 0.8–1.5 m high. *Branchlets* smooth or slightly ribbed, yellow-grey or reddish brown, with a dense indumentum of simple to tightly coiled hairs 0.1–0.3 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight with a strongly recurved apex, 6–9(–11) mm long, 0.4–0.7 mm wide, smooth or rarely faintly scabridulous, glabrous or with very few scattered, straight, white hairs 0.3–0.7 mm long, sometimes more densely hairy towards the base; apex acute, coarsely pungent, the point 0.3–0.5 mm long. *Flower heads* terminating branchlets, sessile, depressed-ellipsoid to globose, 14–20 mm diam. *Involucral bracts* erect, lanceolate to subulate, 3.5–5 mm long, 0.7–1.2 mm wide, with an acuminate apex 1.5–2.5 mm long, viscid, glabrous throughout or occasionally with margins sparsely ciliate. *Floral bracts* ovate to broadly subulate, 4–7 mm long, 1.0–1.8 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1–2 mm long, glabrous towards the apex; inner surface glabrous. *Tepals* 9–12 mm long, with a sparse or moderately dense indumentum of straight or wavy hairs 0.5–1.5 mm long, the lower hairs always distinctly wavy; claw yellow or creamy yellow, glabrous at base; limb 3–4 mm long, viscid, usually glabrous above the top of the anther, with the long hairs attached below this level rarely extending beyond the glabrous apex. *Anthers* 2.0–2.6 mm long. *Pistil* 10–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.0–3.8 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.7–1.2 mm, with scattered patent hairs 0.1–0.15 mm over most of its length; unswollen apical part 0.4–1.3 mm long. *Cones* broadly ellipsoid to globose, 11–21 mm long, 12–19 mm diam.; scales elliptic to broadly ovate, 2–4 mm wide, with a dense indumentum of straight or curly hairs. *Diaspores* elliptic to oblong in outline, 2.2–3.5 mm long including the apical beak formed by the enlarged base of the style and 1.7–2.5 mm long excluding the beak, 1.6–2.3 mm wide, with a coma of straight, white, hairs 2.5–5 mm long mixed with erect, purplish black hairs 0.1–0.2 mm long along the margins and base; adaxial and abaxial surfaces with a longitudinal division down the centre, usually glabrous, rarely with scattered, appressed, white hairs 0.05–0.1 mm long. (Figure 1F)

Selected specimens examined. WESTERN AUSTRALIA: 56.4 km N along Brand Highway from junction of Muchea South Rd, 23 Aug. 2001, *R. Davis* 9944 (PERTH); 67.8 km N of Gingin on Brand Highway, 14 Sep. 1997, *S. Donaldson* 1655 *& G. Flowers* (PERTH); private farmland off Green Head–Coorow road, *c.* 3 km W of Brand Highway, 30 July 1995, *M. Hislop* 67 (PERTH); Brand Highway, 50 km S of Cataby, 24 July 2005, *J.E. Wajon* 1376 (PERTH).

Distribution and habitat. Distributed in the northern sand-plains of the South-West Botanical Province from Warradarge east to Watheroo and south to Wannamal (Figure 2C). Occurs in deep sand or sand over laterite, in vegetation usually dominated by Myrtaceae and/or Proteaceae, often in *Banksia* woodlands.

Phenology. Flowers July to September.

Conservation status. Not considered to be at risk.

Affinities. Petrophile recurva was originally considered by Foreman (his determinavits on the specimens) as a subspecies of *P. scabriuscula* but later named as a distinct species, which can usually be distinguished by the recurved apex on its leaves, the more crinkled indumentum on its tepals and by its shorter involucral bracts and narrower and generally thinner cone scales. There are no obvious ecological differences between the two taxa although they are largely geographically separated, with the distribution of *P. recurva* mostly south of that of *P. scabriuscula*. However, there is a small area of overlap in the region from Warradarge east to Watheroo National Park. In that region, they can generally be readily identified by *P. scabriuscula* having its involucral bracts and tepals not or scarcely viscid whereas *P. recurva* has its involucral bracts (when in flower) and also the apex of its tepals manifestly viscid. *Petrophile recurva* also differs in the indumentum on its tepals, with the upper hairs often somewhat curled or crinkled and the lower ones strongly wavy, whereas *P. scabriuscula* has more numerous, straighter hairs.

Specimens of the new northern taxon *Petrophile foremanii* are more similar in their bract and tepal characters to *P. recurva*, although they still differ in their straighter or more incurved leaves with the apex more erect, and the surface more scabrous. See also the notes under the other new species, *P. globifera*.

Notes. According to Foreman's (1995: 173) description, the leaves in this species are up to 13 mm long, but those seen in the current study rarely exceeded 9 mm long and the largest were 11 mm long.

Petrophile scabriuscula Meisn. *in* J.G.C. Lehmann, *Pl. Preiss.* 1: 495 (1845). – *Petrophile ericifolia* var. *scabriuscula* (Meisn.) Benth., *Fl. Austral.* 5: 331 (1870). *Type*: Swan River Colony [Western Australia], *J. Drummond* 557 (*syn*: K *n.v.*, photograph seen (MEL 2274286, PERTH 01543806), K *n.v.*, photograph seen (MEL 2274287), MEL 1535723).

Illustration. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 159 (1988).

Shrubs 0.4–1.5 m high. *Branchlets* smooth, yellow-grey to brown, with a dense indumentum of tightly coiled hairs and with scattered, straighter hairs 0.4–0.7 mm long, glabrescent. *Leaves* erect, crowded, simple, sub-terete, straight or incurved over most of their length but with the apex sometimes slightly recurved, 6–11(–16) mm long, 0.5–0.8 mm wide, scabridulous, with scattered, straight, white hairs 0.5–1.5 mm long; apex acute, innocuous or coarsely pungent, the point 0.3–0.7 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, depressed-ellipsoid to globose, 15–25 mm diam. *Involucral bracts* erect, lanceolate to subulate, 5–9.5 mm long, 0.8–1.9 mm wide, usually not viscid, with an acuminate apex 2.5–5 mm long that is often markedly recurved, with densely ciliate margins, the longest cilia up to *c.* 2 mm long; outer surface with scattered hairs 0.4–0.5 mm long at the base, usually glabrous above; inner surface glabrous at base, with a dense indumentum above of hairs 0.5–2.2 mm long. *Floral bracts* ovate or narrowly ovate, 4–6.5 mm long, 0.7–2.4 mm wide, acuminate, brown; outer surface and margins with a dense indumentum of straight or wavy hairs 1.0–2.1 mm long, glabrous at apex; inner surface glabrous. *Tepals* 10–14 mm long, with a dense indumentum of straight hairs, the longest hairs 1.5–2.5 mm long; claw creamy yellow, glabrous at base; limb 3.0–3.7 mm long, usually not viscid, the indumentum extending above the top of the anther and with extreme apex of tepal glabrous but with the long hairs protruding beyond the glabrous apex. *Anthers* 1.7–2.4 mm long. *Pistil* 10–16 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 2.9–3.6 mm long; swelling narrowly ovoid to fusiform, glabrous on basal 0.5–1 mm, with patent hairs 0.05–0.1 mm long over most of its length; unswollen apical part 0.3–0.8 mm long. *Cones* ellipsoid to globose, 11–14 mm long, 13–17 mm diam.; scales broadly ovate, 5–7 mm wide, with a dense indumentum of straight or curly hairs, often becoming glabrous apically. *Diaspores* more or less elliptic or obovate in outline, 3.5–5 mm long including the apical beak formed by the enlarged base of the style and 2.0–3.3 mm long excluding the beak, 1.5–3.0 mm wide, with a coma of straight, white hairs 3–5.5 mm long and purplish black hairs 0.05–0.15 mm long on the margins and base; adaxial surface deeply convex, with a longitudinal division down the centre, largely glabrous or with scattered, appressed, white hairs 0.05–0.1 mm long, often with a dense indumentum of minute purplish black hairs at apex. (Figure 1G)

Selected specimens examined. WESTERN AUSTRALIA: 25 km S of Eneabba, 20 July 1978, *R.J. Cranfield* 262 (PERTH); road to Mt Adams, 12.9 km from Brand Highway, 28 May 1997, *R. Davis* 3264 (PERTH); Burma Rd, SE of Walkaway, 20 July 1973, *A.S. George s.n.* (PERTH); Hi Vallee property (D. & J. Williams), Warradarge, bottom of main valley, 10 July 1999, *M. Hislop* 1350 (PERTH).

Distribution. Occurs in the South-West Botanical Province from the Wicherina area south to the Warradarge area (Figure 2D), mostly in sand, sometimes over laterite, in vegetation usually dominated by Myrtaceae and/or Proteaceae, including *Banksia* woodlands.

Phenology. Flowers May to October.

Conservation status. Known from numerous collections extending at least 170 km, this taxon is not considered to be at risk currently.

Affinities. See notes under its three close relatives *Petrophile foremanii*, *P. globifera* and *P. recurva*. This species tends to have the most hairy leaves and tepals found in the *P. scabriuscula* complex, with the longest hairs on its tepals 1.5–2.5 mm long, and usually also tends to have the longest involucral bracts.

Notes. The type collection has unusually large leaves, up to 16 mm long, and large flower heads with the involucral bracts viscid, the closest approach to these characters being seen in the specimen *M. Hislop* 1350 from Hi Vallee farm in the Warradarge area. Across the species' range to the north of Warradarge, specimens of *Petrophile scabriuscula* have shorter leaves and generally lack viscid involucral bracts although matching the type material in other respects.

Petrophile septemfida Rye & K.A.Sheph., *sp. nov.*

Folia teretia, plerumque septemfida, 4–13 mm longi. Tepala dense pilosa. Pollinis praebitor angusta ovoideus ad fusiformus, 2–3 mm longus; pilis patentes. Styli glabris. Nux integris (non alata), basi et margine lato comoso.

Typus: north-east of Badgingarra, Western Australia [precise locality withheld for consertion reasons], 16 August 2008, *M. Hislop* 3804 (*holo*: PERTH 07978014; *iso*: CANB, K, MEL).

Petrophile chrysantha subsp. Watheroo (K.M. Allan 57), in G. Paczkowska & A.R. Chapman, *West Austral. Fl: Descr. Cat.* p. 501 (2000); Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed March 2009].

Shrubs 0.6–1.2 m high. *Branchlets* ribbed, grey, with a dense layer of tightly coiled hairs overlain by much sparser layer of antrorse hairs 0.4 mm long, becoming glabrous in patches. *Leaves* antrorse, usually steeply so, deeply divided mostly into seven lobes, 4–13 mm long, 1.2–8.5 mm diam., terete, with a moderately dense indumentum of hairs to 0.7 mm long, older leaves tuberculate; lobes with a pungent point 0.3–0.8 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, globose, 9–14 mm long, 9–16 mm diam. *Involucral bracts* erect, mostly narrowly ovate, 4–8 mm long, 1.1–2.0 mm wide, acuminate, appearing brown, with densely ciliate margins, the cilia up to 1.2 mm long; outer surface with a moderately dense to dense indumentum of white hairs 0.4–0.9 mm long; inner surface densely covered by hairs 0.9–1.5 mm long. *Floral bracts* ovate, 3.2–3.8 mm long, 0.9–1.4 mm wide, acuminate, brown, longitudinally ribbed; outer surface glabrous towards the apex, base and margins with densely arranged hairs 0.5–1.1 mm long; inner surface with a few hairs *c.* 0.6 mm long at the base, otherwise glabrous. *Tepals* 10.5–13.5 mm long, densely hairy; claw cream or pale-yellow, with patent hairs 0.4–0.8 mm long, glabrous at base; limb 1.9–2.9 mm long, with antrorse hairs 0.5–0.7 mm long. *Anthers* 1.4–1.8 mm long. *Pistil* 11–14 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 1.9–2.9 mm long; swelling narrowly ovoid to fusiform, 0.5 mm diam., glabrous on basal 0.7–1.2 mm, with scattered, patent hairs 0.6–0.13 mm long over most of its length; unswollen apical part 0.2–0.4 mm long. *Cones* globose, 5–11 mm long, 5–10 mm diam.; scales broad. *Diaspores* broadly ovate in outline, 4.8–6.0 mm long including the apical beak formed by the enlarged base of the style and 2.5–3.3 mm long excluding the beak, 2.4–3.5 mm wide, with an erect coma of straight, white hairs 2.8–3.5 mm long on the margins and base; adaxial and abaxial surfaces shortly appressed-hairy. (Figure 1H)

Other specimens examined. WESTERN AUSTRALIA [localities withheld]: 24 July 1969, *K.M. Allan* 57 (PERTH); 30 June 1967, *C. Chapman s.n.* (PERTH); 1 Sep. 1984, *D.B. Foreman* 474 (CANB, MEL, NSW, PERTH); Sep. 1965, *C.A. Gardner s.n.* (PERTH); 1 Oct. 1982, *E.A. Griffin s.n.* (PERTH); 11 Sep. 1985, *N. Hoyle* 200 (PERTH); no locality, Sep. 1953, *A.C. Kessell s.n.* (PERTH 03431681); 8 Sep. 1986, *I.R. McGill* 13 (PERTH); 6 Oct. 1971, *R.D. Royce* 9617 (PERTH).

Distribution and habitat. Occurs from north of Tathra National Park east to near Coorow and south-east to Watheroo National Park in the South-West Botanical Province (Figure 2E). Recorded in sand or in sand over laterite, in shrubland, at one locality growing with *Dryandra* and *Hakea* species.

Phenology. Flowers recorded late June to early October.

Conservation status. Listed by Smith (2010) as Priority Three (DEC Conservation Codes for the Western Australian Flora) under the name *Petrophile chrysantha* subsp. Watheroo (K.M. Allan 57). This species has a range of about 75 km, including two national parks and a reserve.

Etymology. From the Latin *septemfidus* (seven-cleft), as most of the leaves are deeply divided into seven branches. A typical leaf is shown in Figure 1H.

Affinities. This taxon has been confused with *Petrophile chrysantha* Meisn. but differs in many characters including its finer and more hairy leaves, its narrower involucral bracts that are hairy outside, its creamy yellow tepals with a prominent glabrous tip, its glabrous style and its pollen presenter with somewhat shorter and more spreading hairs, and its non-winged diaspore. In *P. chrysantha* the leaves are more scabrous and more prominently pungent, the involucral bracts are glabrous outside but distinctly ciliate, the vividly yellow tepals have longer hairs, and the lower half of the style is hairy.

Petrophile septemfida is more closely related to the species group that includes *P. misturata* Foreman and *P. scabriuscula* but does not appear to have any very close relatives. It differs from members of that group in its finer, more divided leaves with simple, straight, white hairs, and it has a shorter pollen presenter than all or most members of that group.

Petrophile serruriae R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 6 (1830). *Type*: south-west coast of New Holland, [Stirling Range to King George Sound, Western Australia], 1828–1829, *W. Baxter s.n.* (*lecto*: BM 000759018, *fide* D.B. Foreman, *Fl. Australia* 16: 477 (1995); *isolecto*: BM *n.v.*). *Paralecto*: Swan River, [Western Australia], *C. Fraser s.n.* (BM 000759019).

Petrophile glanduligera Lindl., *Sketch Veg. Swan R.* 35 (1840). *Type*: Swan River, 1839 [Western Australia, collected 1835–1838], *J. Drummond s.n.* (*holo:* CGE (2 sheets) *n.v.*, photograph PERTH 01543814; *iso*: K *n.v.*).

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 159 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 97C–E (1995).

Shrubs to 0.2–1.5 m high. *Branchlets* ribbed, grey, with a moderately dense indumentum of patent hairs *c.* 0.1 mm long and scattered hairs 1.0–2.8 mm long. *Leaves* spreading, usually irregularly bipinnatisect, straight, 12–32 mm long, 10–33 mm wide, with a variable indumentum of long and short, often tubercle-based, antrorse hairs to 1.8 mm long; lobes narrow but somewhat compressed, rigid, with a pungent point 0.2–1.2 mm long. *Flower heads* mostly axillary, often pedunculate, ± globose, 15–30 mm long, 18–34 mm diam.; peduncle 3–9 mm long. *Involucral bracts* erect or spreading, narrowly ovate to ovate, 1.2–4.2 mm long, 1.1–3.4 mm wide, obtuse or acute; outer surface with a dense tuft of hairs at the base, glabrous above; inner surface with 1–3 ribs, glabrous. *Floral bracts* ovate or narrowly ovate, 3.9–5.2 mm long, 1.7–2.9 mm wide, acute or acuminate, brown, with glabrous margins; outer surface with a dense indumentum of antrorse hairs to 1.9 mm long in the lower half, glabrous towards the apex; inner surface glabrous. *Tepals* 13–25 mm long, moderately densely hairy; claw yellow, with antrorse hairs 0.4–0.7 mm long, glabrous at base; limb 2.9–4.1 mm long, with hairs 1.1–1.7 mm long rarely exceeding the apex of the limb, with a clavate subapical appendage 0.7–1.2 mm long. *Anthers* 1.2–3.1 mm long. *Pistil* 15–22 mm long, the style with scattered hairs 0.1–0.2 mm long along most of its length. *Pollen presenter* 3.1–5 mm long; swelling narrowly obovoid to fusiform, with a sparse indumentum of fine, retrorse hairs *c.* 0.2 mm long over distal 1/2–2/3, glabrous towards base; glabrous apical part 0.7–1.4 mm long. *Cones* globose to ovoid, 9–21 mm long, 8–17 mm diam.; scales ovate or broadly ovate. *Diaspores* narrowly ovate in outline, 4.9–6.1 mm long, 1.7–2.8 mm wide, including a narrowly triangular, readily detached, terminal wing upon which the style remains often form an apical beak; abaxial surface glabrous in the basal 1/3–2/3, with fine, appressed hairs *c.* 0.1 mm long towards the apex; adaxial surface with a sparse or moderately dense indumentum of white or brown, appressed hairs *c.* 0.1 mm long, these becoming intermixed with the long hairs of the coma about the base and lower margins; coma hairs restricted to base of diaspore, 3.5–5 mm long, white to pale-gold. (Figure 1I)

Selected specimens examined. WESTERN AUSTRALIA: Site 14, Deefor Rd, 3 km SSW Coolakin Spring [SW of York], 11 Nov. 1996, *M.G. Allen* 527 (PERTH); lower slopes of Mt Magog, 1 km from picnic area and along gully at picnic area, 18 km to Stirling Range Drive from Chester Pass Rd, 31 Oct. 1986, *R.S. Cowan* A-546 (NY, PERTH); Reserve No. 30363, Inkpen and Woottating Rds, 4 Dec. 1988, *R.J. Cranfield* 7621 (PERTH); O'Connor Rd Reserve, located on both sides of O'Connor Rd *c.* 695 m NE from its junction with Dardadine South Rd, Shire of West Arthur, 1 Oct. 1999, *J.W. Horn & R. Butcher* 2714 (DUKE, PERTH); Hi Vallee property (D. & J. Williams), Warradarge, track along N head of main valley, 13 Sep. 1999, *M. Hislop* 1543 (PERTH); Tathra National Park, 4.9 km E on Carnamah–Eneabba road from intersection with Touche Rd (*c.* 26.5 km due E of Eneabba), 11 Sep.

1985, *N. Hoyle* 202 (PERTH); 16 km WSW of Badgingarra, 7 Aug. 1973, *A. Kanis* 1529 (CANB, PERTH); Muradup, 25 km W of Kojonup, 5 Nov. 1996, *C. Lewis* CML 67 (PERTH); near Two Mile Lake, Nov. 1988, *W.L. McCaw, R.H. Smith & J.E. Neal s.n.* (PERTH); 25 km SE of Toodyay, 14 Oct. 1989, *B. Nordenstam & A. Anderberg* 699 (PERTH); Yoongarillup, 19 Oct. 1952, *R.D. Royce* 3890 (PERTH); 40 km from Borden on Albany–Borden road, 10 Oct. 2000, *J.F. Smith* 42 (PERTH); Gravel Reserve, Williams Loc. 20020, corner Narrakine and Contine roads, 25 Nov. 1998, *G. Warren* 24 (PERTH).

Distribution and habitat. Occurs mainly in orange-brown, sandy gravel with ironstone in the South-West Botanical Province, extending from near Geraldton south-east to Albany and Cape Riche, with a disjunct occurrence on the Whicher Range in the south-west corner of the State (Figure 2F).

Phenology. Northern plants flower mainly from August to October, while southern plants tend to flower from September to December.

Conservation status. A relatively common, widespread species.

Affinities. See notes under its closest relative *Petrophile axillaris*, which was previously regarded as a synonym.

Notes. This description is needed since the circumscription of this species has been significantly reduced by the reinstatement of *Petrophile axillaris*. There is one record of *P. serruriae* regenerating after fire from a multi-stemmed base but observations by one of us (MH) do not support this. The clavate and outwardly projecting tepal appendage is always conspicuous in *P. serruriae*. The shape of the club varies from globular to almost cylindrical, but even when it is at its narrowest it is still differentiated from the stalk of the appendage by its darker colour.

The Whicher Range populations are separated by a disjunction of over 80 km from the remainder of the range of the species but morphologically seem very similar.

Petrophile trifurcata Foreman, *Fl. Australia* 16: 479 (1995). *Type*: Wongan Hills, Western Australia [precise locality withheld for conservation reasons], 9 September 1983, *P. Roberts* 172 (*holo:* PERTH 03418308; *iso*: MEL *n.v.*).

Illustration. D.B.Foreman, *Fl. Australia* 16: fig. 92 (1995).

Shrubs 0.3–0.65 m high. *Branchlets* ribbed, grey to red-brown, with a moderately dense indumentum of wavy to coiled hairs 0.1–0.4 mm long. *Leaves* antrorse, not crowded, sometimes simple, usually divided distally into 2 or 3 lobes, straight, 11–16 mm long, 0.6–0.7 mm diam., rigid, terete, glabrous; lobes with an acute or pungent point 0.3–1.1 mm long. *Flower heads* terminating branchlets (those from previous growing seasons located at lower junctions where the branchlets arise), sessile, globose, 8–10 mm diam. *Involucral bracts* erect, narrowly ovate or ovate, 2.5–3.75 mm long, *c.* 1.3 mm wide, long-acuminate, densely ciliate on margins with white hairs 0.5–0.8 mm long; outer surface glabrous; inner surface glabrous towards the base, densely hairy above with hairs similar to the marginal cilia. *Floral bracts* ovate, 3–4 mm long, *c.* 1.5 mm wide, acute, brown; outer surface glabrous towards the apex, with a dense indumentum of curly hairs 0.6–1 mm long in the lower half; inner surface densely hairy at the base, glabrous above. *Tepals* 8–11 mm long, with a moderately dense indumentum of somewhat curled hairs 0.4–1 mm long; claw yellow or pale-yellow, glabrous at base; limb *c.* 3 mm long, with a glabrous apex *c.* 0.4 mm long. *Anthers c.* 2 mm long. *Pistil* 10–15 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 2–3 mm long; swelling fusiform, glabrous on basal 0.4–0.6 mm, with a moderately dense indumentum of patent hairs 0.1–0.2 mm long over most of its length; unswollen apical part 0.3–0.4 mm long. *Cones* globose, 12–15 mm long, 12–18 mm diam.; outermost scales very broadly elliptic or depressed-elliptic. *Diaspores* broadly obovate in outline, 3–3.5 mm long including an apical beak 0.5–0.6 mm long, 2.5–3.5 mm wide, with an erect coma of white hairs 4–5 mm long and brown or dark-purplish hairs 0.2–0.3 mm long along the margins and base; abaxial surface glabrous or with short, appressed hairs towards margins, fairly flat; adaxial surface glabrous except for short, appressed hairs along the centre or towards margins, flattened on each side of a raised longitudinal rib along the centre. (Figure 1J)

Other specimens examined. WESTERN AUSTRALIA [localities withheld]: 23 Feb. 2000, *P. Armstrong s.n.* (PERTH); 13 Sep. 1932, *W.E. Blackall* 2574 (PERTH); 8 Oct. 1992, *E.A. Griffin* 7166 (PERTH).

Distribution and habitat. Occurs from near Coorow south-east to Wongan Hills in the South-West Botanical Province (Figure 2G). Recorded in sandy soils, with *Actinostrobus arenarius*.

Phenology. Flowers recorded from early September to early October. A fruiting specimen collected in late February still has the remnants of old flowers attached, suggesting the flowering period for this species may continue until January or early February.

Conservation status. DEC Conservation Codes for the Western Australian Flora: Priority Two (Smith 2010). This species is known from four collections over a distance of at least 100 km, with one of the collections from a nature reserve.

Affinities. Closely related to *Petrophile misturata* and superficially similar to the hybrid *P. ericifolia* × *seminuda,* which keys out together with it in couplet 37. See the discussion under the hybrid.

Notes. The most recently collected specimen of *Petrophile trifurcata* differs from the rest in having only a few of its leaves divided. This raises the possibility that some plants of this species may have all of their leaves simple and might therefore not key out in the species key given above. The closely related species *P. misturata* certainly has some specimens with all of their leaves simple.

Description of the presumed hybrid

Petrophile ericifolia × seminuda

Shrubs 0.6–1.2 m high. *Branchlets* ribbed, grey to red-brown, with a moderately dense indumentum of wavy to coiled hairs 0.05–1 mm long, glabrescent. *Leaves* antrorse, not crowded, distally divided into 2 or 3, when 3 the central one sometimes further divided into 2 or 3 lobes, straight, 15–25 mm long, 4.5–6 mm diam., rigid, terete, glabrous; lobes 2–5, with a pungent point 0.2–0.5 mm long. *Flower heads* terminating branchlets, sessile, globose, 20–25 mm long, 16–22 mm diam. *Involucral bracts* erect, narrowly ovate to ovate, 2.7–6 mm long, 1.2–2 mm wide, acuminate, appearing darker towards the apex, with densely ciliate margins, the conspicuous white cilia up to 0.4 mm long; outer surface glabrous; inner surface glabrous towards the base, appressed-hairy above. *Floral bracts* ovate, 6.2–7.8 mm long, 2.2–3.6 mm wide, acute, yellowish brown, longitudinally ribbed, viscid; outer surface with a dense indumentum of curly hairs 1.7–2 mm long in the lower half, glabrous towards the apex; inner surface glabrous. *Tepals* 11–13 mm long, moderately densely hairy; claw yellow,with slightly twisted, antrorse hairs 0.2–0.3 mm long, glabrous at base; limb 2.5–3.8 mm long, viscid, with steeply antrorse, slightly twisted hairs 0.2–0.4 mm long, becoming glabrous towards the apex. *Anthers* 1.9–2.2 mm long. *Pistil c.* 13 mm long, the style glabrous except for the pollen presenter. *Pollen presenter* 3.1–3.9 mm long; swelling fusiform, glabrous on basal 0.4–0.6 mm, moderately densely hairy above with patent hairs 0.1–0.2 mm long; unswollen apical part 0.3–0.6 mm long. *Cones* depressed-globose, 16–18 mm long, 20–23 mm wide; scales broadly ovate, 4–6 m wide. *Diaspores* obovate to elliptic in outline, 3.8–4.5 mm long including apical beak and 2.6–3.2 mm long excluding the beak, 1.8–2.5 mm wide, with an erect coma of white hairs 2.5–4.3 mm long and minute dark-red hairs 0.05–0.1 mm long along the margins and base; abaxial surface glabrous, fairly flat; adaxial surface ± glabrous, with a raised longitudinal rib along the centre. (Figure 1K)

Specimens examined. WESTERN AUSTRALIA: [locality withheld] 15 Oct. 2009, *A. Coates* 6035 (PERTH); 15 Oct. 2009, *A. Coates* 6036 (PERTH); 5 Oct. 1998, *A.E. Slarke* 44 (PERTH).

Distribution and habitat. Recorded from west of Lake Grace in the South-West Botanical Province (Figure 2G), on a gentle slope in sandy gravel over clay.

Phenology. Flowers in September and October.

Conservation status. This hybrid is currently known from two plants at a single locality.

Notes. In October 2009, two plants of the hybrid were collected (*A. Coates* 6035, 6036) growing with the presumed parents, *Petrophile ericifolia* R.Br. subsp. *ericifolia* (*A. Coates* 6038) and *P. seminuda* Lindl. (*A. Coates* 6037). Both parent species belong to *Petrophile* RBr. ex J.Knight sect. *Petrophile* and they have similar flowering periods. There is a large area of overlap in their distributions but they may not often grow together as they may tend to differ in habitat preference, with *P. seminuda* showing a greater tendency to occur in lateritic habitats.

The two recent specimens of the hybrid were recorded as 1 m and 1.2 m high respectively but a specimen collected at the same locality in 1998 was recorded as 0.6 m high. If one or both of the plants sampled in 2009 were previously sampled in 1998 then they have probably doubled in height over that period. The previously collected specimen had longer leaves, up to 21 mm, but this may reflect seasonal or other variation in the environmental conditions when the two samples were taken.

The parent taxa and the hybrids all have young stems that are hairy at first but soon glabrescent, terete leaves, sessile flower heads, involucral bracts that are glabrous on the outer surface, yellow tepals, a glabrous style, and a fusiform pollen presenter with more or less patent hairs. The hybrid resembles each of the parent species in one or two characters but is intermediate in most (Table 1). For example its leaves are intermediate in length between those of the two parent species at the site.

Previously the hybrid was considered on the basis of its unusual morphology to be closely related to *Petrophile trifurcata* and *P. misturata*, all three taxa having curled hairs on the young stems, very similar diaspores and leaves tending to be divided distally into 2–5 branches. Unlike the hybrid,

Table 1. Morphological comparison of the presumed hybrid and its two parent species of *Petrophile* collected near Lake Grace in October 2009. A total of four specimens were sampled, one of each parent and two of the hybrid.

Character	***Petrophile ericifolia***	***Petrophile* hybrid**	***Petrophile seminuda***
Indumentum of young stems	± straight or crisped	crisped or curled	tightly curled
Leaf shape	simple	with 2–4 divisions	with 4–9 divisions
Leaf maximum length	*c.* 10 mm	*c.* 15 mm	*c.* 45 mm
Involucral bracts	viscid	viscid	dry
Marginal hairs of involucral bracts	absent	crisped or curled	curled
Tepal length	14–15 mm	10.5–13 mm	8–10 mm
Tepal indumentum	sparsely hairy	sparsely hairy	glabrous
Pollen presenter length	3.8–4.5 mm	3.0–3.9 mm	2.3–3.0 mm

P. misturata and *P. trifurcata* are also known to produce simple leaves, the former species readily distinguished from the hybrid by the more persistent indumentum on its stems and leaves, and the latter differing in having non-viscid flower heads with fewer flowers.

Notes on other taxa

Petrophile crispata R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 6 (1830). *Type*: south-west coast of New Holland [Stirling Range to south coast, Western Australia], 1828–1829, *W. Baxter s.n.* (*holo*: BM 000759017).

Illustrations. No published illustrations have been found. The illustration labelled *Petrophile crispata* in Blackall and Grieve (1988: 162) is clearly not this species as it is keyed and shown as having hairy tepals.

Notes. Although Brown (1830) gave the type locality as 'King George's Sound', this species is not known from the vicinity of the sound and is likely to have been collected either further east along the coast or inland towards or on the Stirling Range, as most of William Baxter's collections came from those areas. More recently collected specimens from the Stirling Range to Cape Riche region have short tepals 8–10 mm long, a small pollen presenter 2.5–3.5 mm long, and numerous, short, broad involucral bracts, which are always glabrous on the outside (but densely hairy inside). Some adjacent areas inland to Ongerup, west to Unicup and eastwards along the south coast have similar specimens. These have been identified as *Petrophile crispata* while the remaining PERTH specimens, ones with narrower involucral bracts, are currently identified as a broadly defined *P. seminuda* and the combined group is referred to here as the *P. crispata* complex. In western and most inland areas, the involucral bracts in this complex are often hairy as well as invariably being narrower than those of *P. crispata s. str.* and there may be relatively few of them. Specimens currently housed under *P. seminuda s. lat.* are much more widespread and variable than those housed as *P. crispata*, including having tepals 8–13.5 mm long and pollen presenters 3–5 mm long. For further details of these variants see the notes under *P. seminuda*.

In the region surrounding Hopetoun there are some specimens that appear somewhat intermediate between *Petrophile crispata* and *P. seminuda s. lat.* in their involucral bracts, and the whole complex undoubtedly needs further work to determine how many taxa should be recognised and at what rank. If the two currently accepted taxa should prove to be conspecific, *P. seminuda* will become a synonym of the older name *P. crispata*.

The involucral and/or floral bracts of some specimens of this complex are obviously viscid while those of other specimens appear to be dry. This may reflect seasonal or microclimatic differences at the time of collection and differences in the drying of the specimens or may be due to differences in the genetic make-up of the specimens.

Petrophile incurvata W.Fitzg., *J. Bot.* 50: 22 (1912). *Type*: Watheroo rabbit fence, Western Australia, September 1905, *M. Koch* 1522 (*syn*: PERTH 04381025, PERTH 06539009).

Petrophile semifurcata var. *planifolia* F.Muell., *Fragm.* 10: 47 (1876). *Type*: near Mt Churchman, Western Australia, *J. Young s.n.* (*holo*: MEL *n.v.*).

Petrophile conifera var. *incurvata* (F.Muell. ex Benth.) C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 157 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 96D&E (1995).

Description as given in Foreman (1995: 185).

Affinities. This species is closely related to *Petrophile conifera* and *P. semifurcata*, but is readily distinguished from both species by its flattened leaves. It occurs south of the range of both *P. semifurcata* and *P. conifera* subsp. *conifera* but the northernmost part of its range encloses the very small area where *P. conifera* subsp. *divaricata* occurs.

Notes. Mueller (1876) regarded *Petrophile incurvata* as a variety of the next species, *P. semifurcata*, whereas Gardner (unpub.) considered both of them to be varieties of *P. conifera*. Foreman (1995) treated all three as distinct species; his treatment omitted all unpublished synonyms.

Petrophile semifurcata F.Muell. ex Benth., *Fl. Austral.* 5: 335–336 (1870). *Type*: Murchison River, Western Australia, *A.F. Oldfield s.n.* (*holo*: K *n.v.*, photograph seen (MEL 22742880); *iso*: MEL 1524421, 1534422).

Petrophile conifera var. *semifurcata* (F.Muell. ex Benth.) C.A.Gardner ms, *Flora of Western Australia* 1(3): 95 (unpubl.); *in sched.* (PERTH)

Petrophile sp. Zuytdorp (P. Roberts 761), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed April 2009].

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 161 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 96J–M (1995).

Description as given in Foreman (1995: 185) except that the leaves can also be simple.

Affinities. This species is closely related to *Petrophile conifera*, differing in its usually more erect leaves, which are often simple or have few divisions, its pedunculate flower heads and its more appressed hairs on the tepals. Its pollen presenter also tends to be longer and more cylindrical. The two species become more similar in leaf morphology, and therefore harder to distinguish when not in flower, in the southern parts of their ranges.

Notes. Based on the long, more or less cylindrical pollen presenter found in *Petrophile semifurcata*, Bentham (1870) erected a new section just for this species. He correctly noted that the species could have entire leaves, but Foreman (1995) described it as always having divided leaves and only included it in the part of the key for species with divided leaves. Consequently, simple-leaved specimens keyed out to *P. stricta* R.Br. and two of these that lacked mature flowers were given the informal name *Petrophile* sp. Zuytdorp (P. Roberts 761), which is here reduced to a synonym of *P. semifurcata*. Specimens with all of their leaves simple, or with a mixture of simple and divided leaves, are fairly common in the northern part of the geographic range but all southern specimens have divided leaves.

An earlier unpublished synonym, that of Gardner's listed above, was not listed in Foreman's (1995) treatment of the genus.

Petrophile seminuda Lindl., *Sketch Veg. Swan R.* 34 (1840). *Type*: Swan River District [Western Australia], 1837, *J. Drummond s.n.* (*lecto*: CGE, *fide* D.B. Foreman, *Fl. Australia* 16: 477 (1995) *n.v.*, photograph seen). *Other material:* Swan River District [Western Australia, 1839], *D. Toward* 42 (*lectopara*: CGE *n.v.*, photograph seen).

Petrophile seminuda var. *indivisa* Benth., *Fl. Austral.* 5: 333 (1870). *Type*: Western Australia, *J. Drummond s.n.* (*lecto*: K specimen on right side of sheet 000035126, here selected, photograph MEL 2147396; *lectopara*: K specimen on left side of sheet 000035126, photograph MEL 2147396).

Isopogon pedunculatus R.Br., *Suppl. Prodr. Fl. Nov. Holl.* 7–8 (1830). *Type*: Swan River, [Western Australia], 1827, *C. Fraser* 8 (*holo*: BM 000759012).

Illustration. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 160 (1988).

Conservation status. A relatively common, widespread species.

Lectotypification. The K type sheet of *Petrophile seminuda* var. *indivisa* has two pieces mounted, the larger one on the right with all leaves entire being selected here as the lectotype. The specimen on the left appears to have been collected from a separate plant, as it has somewhat broader leaves, with some of the leaves divided, and a narrower fruiting cone; it is therefore treated as a lectoparatype. It is likely that this variant was collected from near Perth and coexists with specimens that have divided leaves as it resembles material collected from the Lower Canning River by *A. Morrison* in 26 Oct. 1899, which has two pieces with divided leaves (α, β) and one with undivided leaves (γ). The latter specimen is mounted together with several specimens with divided leaves and appears to be an insignificant variant coexisting with the normal variant.

Affinities and synonyms. See notes under its closest relative *Petrophile crispata.* The oldest available name, *Isopogon pedunculatus*, cannot be used for *P. seminuda* by making a recombination because the epithet *pedunculata* has already been used for a *Petrophile* species from eastern Australia. In flower, *P. seminuda* has sessile flower heads in the sense that there is no peduncle below the base of the lowest involucral bracts, although in some of the fruiting specimens (e.g. *D.B. Foreman* 1105) the involucral bracts have been shed, revealing a very short, bare stalk that could be mistaken for a peduncle. The type material of *I. pedunculatus* is in fruit and resembles the *Foreman* specimen, including having a short, peduncle-like region, hence the choice of its epithet.

Variants. Many variants are known, occurring widely in the South-West Botanical Province and extending into the South-western Interzone. The typical variant occurs on the eastern side of the Swan Coastal Plain and on the Darling Range near Perth, mainly from Chittering south to Jarrahdale, and has long leaves with few to many, slender ultimate divisions, or rarely the leaves are simple as discussed above. Its involucral bracts are glabrous on the outer surface, subtending large, dense flower heads, and the pollen presenter has short to long hairs.

The variant occurring furthest north, which always has multi-divided leaves, tends to have even larger flower heads and longer hairs on the pollen presenter than the typical variant. In the Perth region, there is a second main variant, i.e. in addition to the typical variant noted above, associated with swamps on the coastal plain and extending north to Lesueur National Park. The western swamps variant has its leaves commonly just divided into three but sometimes with most leaves divided further, its few-flowered heads subtended by involucral bracts that are glabrous on the outer surface, and its pollen presenter either glabrous or with very short hairs. Specimens with the involucral bracts hairy outside are common in the Eneabba area and extend south-east to east of Hyden, but are absent from the Perth region, the far north and regions close to the south coast. Towards the south coast, specimens of *Petrophile seminuda s. lat.* seem to intergrade with those of *P. crispata* and so identification of the two taxa is problematic.

The furthest inland specimens are those from between Southern Cross and Kalgoorlie. All of these specimens have fruiting cones but lack flower heads so their involucral bracts and flowers have not been examined. Flowering material needs to be obtained for this region to determine how these specimens compare with others in the *Petrophile crispata* complex. Three of the variants which differ from the description given by Foreman (1995: 160) for *P. seminuda* are briefly treated below.

a. northern variant

Selected specimens examined. WESTERN AUSTRALIA: Kalbarri National Park, 38 km by main road from waterfront and 0.5 km N of road, 10 Oct. 1996, *M.G. Corrick* 11386 *& B.A. Fuhrer* (PERTH); Bullock Rd, 6 km NE of homestead, Riverside Ajana property (R. & D. Porter), E of Galena, 30 Nov. 2000, *D.M. Porter* 31 (PERTH).

Distribution and habitat. Occurs in the north of the South-West Botanical Province, in yellow or white sand over gravel, extending from near Ross Graham Lookout in Kalbarri National Park east to beyond Galena. Possibly the same variant occurs east of Geraldton, from near Ambania south to Indarra Springs Reserve, where it is recorded in sand over limestone, and also in some areas further south.

Notes. The distribution map for *Petrophile seminuda* currently on *FloraBase* (Western Australian Herbarium 1998–) has a disjunction in the north between the specimens from the Kalbarri area and the next closest specimens from east of Geraldton, but the latter ones seem to have very similar morphology. This northern variant probably extends southwards, overlapping in range, and perhaps intergrading, with the variant that commonly has the outside of the involucral bracts hairy. It differs from Foreman's (1995: 160) description in having numerous, relatively long hairs on the pollen presenter.

b. variant with hairy bracts

Selected specimens examined. WESTERN AUSTRALIA: Corrigin Reserve, 5 June 1998, *E. Bennett* CG 4.3 (PERTH); 11.2 km N along Vermin Proof Fence from junction of Norseman–Hyden track, 29 Oct. 2002, *R. Davis* 10502 (PERTH); 3 km N of Mungedar Rd turnoff on Badgingarra Rd, 31 Aug. 1984, *D.B. Foreman* 414 (AD, CANB, K, NSW, all *n.v.*, PERTH).

Distribution and habitat. Occurs in yellow or white sand over gravel, from the Eneabba area south-east to beyond Hyden. Possibly the same variant occurs from near Ambania south to Indarra Springs Reserve, where it is recorded in sand over limestone.

Foreman's (1995: 160) description of *Petrophile seminuda* describes the involucral bracts as being glabrous outside, as they are for the majority of specimens. However, many specimens from the Eneabba area south-east to near Hyden have their involucral bracts sparsely to densely hairy outside. This character on its own cannot be used to define a subspecies or other category as it coexists with specimens that have the normal glabrous outer surface on the involucral bracts. Recent collections from Corrigin, for example, have involucral bracts varying from glabrous (e.g. *R. Campbell* 395) to densely hairy outside (*E. Bennett* CG 4.3).

c. western swamps variant

Selected specimens examined. WESTERN AUSTRALIA: Cockatoo Rd, 3.5 km NE of Wabling Hill in Reserve 24436, 28 Oct. 1993, *N. Gibson & M.N. Lyons* 1407 (PERTH); Carrabungup Nature Reserve, part of Austin Bay Nature Reserve, SW of Pinjarra, 9 Oct. 1995, *G.J. Keighery* 13973 (PERTH); 10 km E of Nambung Homestead along Wongonderrah Rd, 30 Oct. 1999, *R. Orifici* LE 34.22 (PERTH).

Distribution and habitat. Occurs in near-coastal areas from Lesueur National Park south to Austin Bay Nature Reserve, mostly associated with swamps.

Notes. The pollen presenter normally has very short hairs, but sometimes this indumentum is very sparse or entirely absent as in all three specimens cited above. The complete lack of hairs on the pollen presenter of some specimens deviates from Foreman's (1995: 160) description. The correlation between the distribution and habitat preferences of this variant, its leaf characters as outlined earlier and its pollen presenter characters suggest that this might represent a distinct subspecies or species within the *Petrophile crispata* complex.

Petrophile squamata R.Br., *Trans. Linn. Soc. London* 10: 70 1810). *Type*: towards Cape How [Lake Powell, Western Australia], December 1810, *R. Brown s.n.* (*lecto*: BM *n.v.*, *fide* D.B. Foreman, *Fl. Australia* 16: 478 (1995)).

Petrophile propinqua R.Br., *Suppl. Prodr. Fl. Holl.* 7 (1830). – *Petrophile squamata* var. *propinqua* (R.Br.) C.A.Gardner ms. *Type*: Swan River Colony [Western Australia, 1827], *C. Fraser* 4 (*lecto:* BM *n.v.*, *fide* D.B. Foreman, *Fl. Australia* 16: 476 (1995); *isolecto*: BM *n.v.*).

Petrophile colorata Meisn. *in* J.G.C. Lehmann, *Pl. Preiss.* 2, 246 (1848). – *Petrophile squamata* var. *colorata* (Meisn.) C.A.Gardner ms. *Type*: Swan River Colony [Western Australia, 1827], *J. Drummond* coll. 2, no. 296 (*iso*: MEL *n.v.*; PERTH 01593404 (photograph), PERTH 04244893).

Other synonyms as listed by Foreman (1995: 191).

Illustrations. W.E.Blackall & B.J.Grieve, *How Know W. Austral. Wildflowers* 1: 155,156 (1988); D.B. Foreman, *Fl. Australia* 16: fig. 97B (1995).

Notes. Many names have been published for this difficult species complex, all listed by Foreman (1995) and most not repeated above. However, two manuscript names in Gardner (unpub.: 86) are given above as they were not included in Foreman's treatment, and one of Gardner's illustrations, reproduced here as Figure 3, evidently includes four parts (J–M) drawn from the type of *Petrophile colorata* as that was the only specimen cited for this taxon.

Currently three subspecies are recognised informally. The typical subspecies, *Petrophile squamata* R.Br. subsp. *squamata*, extends from the south-west corner of the State east to Mt Manypeaks (but with a significant disjunction in its known range between the Scott River area and the Walpole area) and extends north at least to Wagerup. *Petrophile squamata* subsp. Ravensthorpe (E.M. Bennett 2597), which was previously known as *P. squamata* subsp. *integra* Keighery ms, is mainly found in the Fitzgerald River region but has outliers in the west near Mt Success in the Stirling Range and in the east near Stokes Inlet. These two subspecies are so distinct that they could easily be recognised as distinct species if it were not for the existence of the third, more widespread subspecies, *P. squamata* subsp. northern (J. Monks 40).

This northern taxon extends from Armadale east to Cape Arid and was once regarded as a separate species, *Petrophile propinqua*, which is included above among the list of synonyms. However, reinstatement of *P. propinqua* does not appear to be supported as *P. squamata* subsp. northern (J. Monks 40) seems to intergrade too completely with subsp. *squamata* in the region from Darling Range to north of Stirling Range. The northern subspecies does not reach the south-coastal region where subsp. *squamata* is most common but overlaps with virtually the entire range of the Ravensthorpe subspecies. It differs from the typical subspecies in having usually narrower and more hairy bracts. There are also slight differences in the style, with *P. squamata* subsp. *squamata* having a glabrous pollen presenter with a long, slender summit whereas the northern subspecies usually has minute hairs on the pollen presenter and a broader, more suddenly contracting, swollen base.

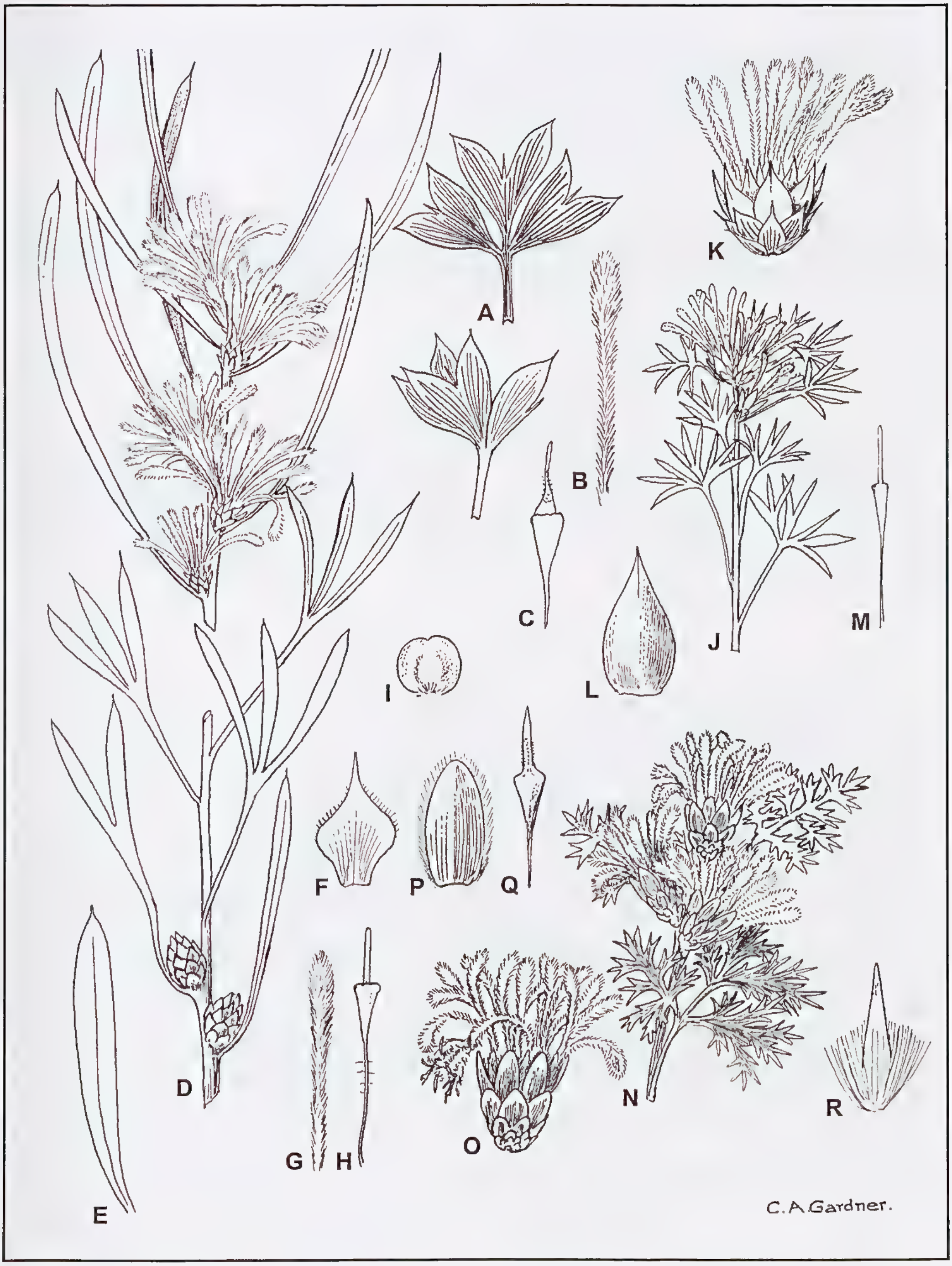

Figure 3. *Petrophile* illustration drawn by C.A. Gardner (Plate XIII [as XIX] of unpublished bound cópy of *Flora of Western Australia* vol. 1, part 3). A–C. *P. biloba*. A – leaves; B – flower bud; C – pollen presenter. D–I. *P. heterophylla*. D – habit; E – leaf; F – floral bract; G – flower bud; H – upper half of style; I – diaspore. J–M. *P. squamata* var. *colorata*. J – habit; K – flower head; L – bract; M – pollen presenter. N–R. *P. striata*. N – habit; O – flower head; P – floral bract; Q – pollen presenter; R – diaspore.

Petrophile squamata subsp. Ravensthorpe (E.M. Bennett 2597) is the most easily recognised subspecies because of its large, entire leaves, which are 4–10 mm wide, but one specimen has most of its leaves divided. This subspecies is identical with the northern subspecies in its involucral bracts and pollen presenters and some specimens of the northern taxon from the region of overlap have their lower leaves entire, although in this case only 2.5–4 mm wide. Still, there is a possibility that these two subspecies do intergrade completely in the Ravensthorpe area.

There might also be differences in habit and habitat preferences of the variants in the *Petrophile squamata* complex, as both single-stemmed and resprouter specimens have been recorded, and they have been recorded in rocky and swampy habitats. This complex has been under study by Greg Keighery.

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References

Bentham, G. (1870). Proteaceae. *In*: *Flora Australiensis*. Vol. 5, pp. 315–584. (Lovell Reeve & Co.: London.)

Blackall, W.E. & Grieve, B.J. (1988). *How to know Western Australian wildflowers*. Part 1. Restructured and revised 2nd edn by B.J. Grieve. (University of Western Australia Press: Nedlands, WA.)

Brown, R. (1830). Proteaceae novas. *Prodromus florae Novae Hollandiae*. Supplement. (R. Taylor: London.)

Cranfield, R.J. & Macfarlane, T.D. (2007). A new species of *Petrophile* (Proteaceae) from south-western Australia. *Nuytsia* 17: 153–158.

Department of the Environment, Water, Heritage and the Arts (2008). *Interim Biogeographic Regionalisation of Australia (IBRA), Version 6.1*. http//www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html [accessed April 2009]

Foreman, D.B. (1990). New species of *Petrophile* R.Br. (Proteaceae) from Western Australia. *Muelleria* 7: 301–310.

Foreman, D.B. (1995). *Petrophile*. *In*: *Flora of Australia*. Vol. 16, pp. 149–193, 446–450, 474–479. (CSIRO Publishing: East Melbourne.)

Gardner, C.A. (unpubl.). *Flora of Western Australia*. Vol. 1, part 3. Proteaceae (*Persoonia–Petrophile*).

George, A.S. (1998). Proteus in Australia. An overview of the current state of taxonomy in the Australian Proteaceae. *Australian Systematic Botany* 11: 257–266.

Hislop, M. & Rye, B.L. (2002). Three new early-flowering species of *Petrophile* (Proteaceae) from south-western Australia. *Nuytsia* 14: 365–374.

Hollister, C., Lander, N.S. & Thiele, K.R. (in prep.). Key to *Petrophile* and *Isopogon* in Western Australia.

Keighery, G.J. (2010). A new species of *Petrophile* (Proteaceae) from the Whicher Range. *The Western Australian Naturalist* 27: 103–106.

Lamont, B. (1985). The significance of flower colour change in eight co-occurring shrub species. *Botanical Journal of the Linnean Society* 90: 145–155.

Mueller, F. (1876). *Fragmenta phytographieae Australiae*. Vol. 10. (Government Printer: Melbourne.)

Rye, B.L. & Hislop, M. (2005). A taxonomic update of *Petrophile* section *Arthrostigma* (Proteaceae). *Nuytsia* 15: 457–483.

Smith, M.G. (2010). *Declared Rare and Priority Flora List for Western Australia*. (Department of Environment and Conservation: Kensington, WA.)

Western Australian Herbarium (1998–). *FloraBase—the Western Australian Flora.* Department of Environment and Conservation. http//www.dec.wa.gov.au/ [accessed April 2009]

Weston, P.H. & Barker, P.B. (2006). A new suprageneric classification of the Proteaceae, with an annotated checklist of genera. *Telopea* 11: 314–344.

Stackhousia stratfordii (Celastraceae: Stackhousioideae), a remarkable new species from a remote location near Norseman, south-west Western Australia

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Abstract

Barker W.R. & Cockerton G.T.B. *Stackhousia stratfordii* (Celastraceae: Stackhousioideae), a remarkable new species from a remote location near Norseman, south-west Western Australia. *Nuytsia* 21(2): 69–74 (2011). *Stackhousia stratfordii* W.R.Barker & Cockerton *sp. nov.* possesses attributes unique to its genus and subfamily of opposite sub-radical leaves and flowers borne in scapes and containing three stamens. Morphological evidence is summarised arguing its placement within *Stackhousia*.

Introduction

The Stackhousioideae Burnett are a subfamily distinctive in Celastraceae R.Br. for their herbaceous life-form, mainly moth-pollinated, tubular flowers, and fruits that are single-seeded indehiscent mericarps (cocci) (Barker 1983, 1984, in press); in terms of diversity they are centred in Australia, occurring in much of the continent, in temperate, arid, semi-arid and sub-tropical regions. Until recently a separate family (Stackhousiaceae R.Br.), the subfamily has morphological and geographic features unique in the family Celastraceae, in which they have been placed in the last decade (Kubitzki 2004a, b; Simmons 2004 a, b). It comprises three genera: *Tripterococcus* Endl. with three species, confined to south-west Western Australia, *Macgregoria* F.Muell., a single species spread across the southern half of arid Australia, and *Stackhousia* Sm. with over 30 species spread over the geographical and climatic range of the subfamily in Australia, with a single species in New Zealand and another spread into Malesia, the Philippines and Micronesia (Barker, in press).

Several species, groups of species and the two smaller genera in the Stackhousioideae have unusual features, most notably *Tripterococcus* with its cocci that detach by the acropetal splitting of the gynophore and *Macgregoria* with its free petals, appendaged anthers, style encircled by a membranous cup and hooked eglandular hairs on the cocci. Within *Stackhousia* there are other morphological rarities (see e.g. Barker, in press), including the following: blue flowers in *S. tryonii* F.M.Bailey in eastern Queensland; umbelliform inflorescences in *S. umbellata* C.A.Gardner & A.S.George from a coastal arid range in north-west Western Australia; the very long style in *S. dielsii* Pamp. in south-west Western

Australia; winged cocci in *S. megaloptera* F.Muell. of the arid-zone sand dunes and *S. spathulata* Sieber ex Spreng. of coastal sands and calcrete pavements in south-eastern and eastern Australia (likely a plesiomorphic state shared with *Tripterococcus*); and solitary flowers in the subalpine *S. pulvinaris* F.Muell. in Australia and *S. minima* Hook.f. in New Zealand.

Stackhousia stratfordii W.R.Barker & Cockerton *sp. nov.*, described herein as new, similarly has unusual features. It is known only from the type collection and associated photographs from the type population. Unique in the subfamily are its opposite leaves clustered at ground level, its inflorescences borne on scapes, and its flowers with three stamens. The opposite arrangement of leaves is evident from the tightly packed branches in the limited material available, but should be confirmed in a wider sample of plants.

Relationships and generic placement

Before the advent of cladistics and the concept of monophyly (Hennig 1966), this species would have been described in a remarkable new genus, so great are its differences from other genera in the Stackhousioideae. However, the most striking of these are unique to this species and hence are uninformative as to its relationships; shared derived character states (synapomorphies) are required to ascertain the phylogenetic placement of taxa.

The new species has a widely spread, herbaceous fruiting hypanthium and a short style, and its cocci are attached near their base to the gynophore; these are derived character states that are not shared by all species in the genus. As a result, on current evidence these features place it firmly within *Stackhousia*. Morphological features are dealt with further in a taxonomic review of the subfamily (Barker in press) and will be described in more detail in a paper on phylogeny and classification within the subfamily based on current morphological and molecular studies (W.R. Barker & D.O. Burge, in preparation). A preliminary phylogeny of the subfamily based on molecular analysis appears in Burge & Barker's (2010) paper on the origins of high levels of nickel uptake in the Queensland species *S. tryonii* F.M.Bailey. Material from specimens of *S. stratfordii* is being analysed for nickel content.

Several species of *Stackhousia* have apparently plesiomorphic (ancestral) character states (shared with *Tripterococcus*, which recent molecular studies indicate is sister to a clade comprising *Stackhousia* and *Macgregoria*: Zhang & Simmons 2006; Simmons *et al.* 2008). For example, *Stackhousia georgei* Diels shares with *Tripterococcus* an elongated zone of coccus attachment almost as long as the cocci; this may be homologous with the axis of the capsules in related genera of Celastraceae (Zhang & Simmons 2006; Simmons *et al.* 2008; Simmons 2004a) which runs their full length. *S. dielsii* possesses a very long gynophore with a very long style, which may be homologous with the long gynophore of *Tripterococcus* and long axis of the capsules of *Peripterygia*. It also shares with two unnamed species of *Tripterococcus* (Barker, in press) a hard, thick, cup-shaped fruiting hypanthium with the cocci supported above it; *T. brunonis* Endl. is slightly divergent in this feature. Two other species in *Stackhousia, S. sp. Swollen gynophore (W.R. Barker 2041)* (being given a formal name by Barker, in press) and *S. occidentalis* Domin, have cocci borne above the hypanthium, though the hypanthium remains more obviously membranous in fruit like other *Stackhousia* species and is filled with a cartilaginous core. *S. spathulata* and *S. megaloptera* possess winged cocci, apparently homologous with the winged cocci of *Tripterococcus* and the narrow wing-like carpels of the capsular fruits of *Peripterygia.* Accordingly, on this best available evidence, all these species possess character states that are apparently plesiomorphic in *Stackhousia*, and are likely to be early-derived species. That these apparently plesiomorphic character states (present in both *Tripterococcus* and *Stackhousia*) are not represented in our new species points to placing it within *Stackhousia*; it has presumably speciated later in the diversification of *Stackhousia* than the other species or their ancestors in the genus with these plesiomorphic states.

Taxonomy

For a generic description and key to species of *Stackhousia*, adjusted to account for this new species, see Barker (in press), which deals also with the taxonomy of the Stackhousioideae. Further molecular and morphological work is being undertaken to produce a whole-evidence based phylogeny of the subfamily and infrageneric classification of *Stackhousia* (W.R. Barker & D.O. Burge, in preparation). A preliminary molecular study is incorporated in a study of the origins of nickel uptake in the Queensland species *S. tryonii* F.M.Bailey (Burge & Barker 2010).

Stackhousia stratfordii W.R.Barker & Cockerton, *sp. nov.*

A speciebus totis *Stackhousiae* Sm. a foliis rosulatis, oppositis, inflorescentibus scapis, et staminibus tribus differt.

Typus: 50 km west of Norseman, Western Australia, 8 October 2009, *G. Cockerton* LCH 26184 (*holo*: PERTH 07702868; *iso*: AD 243532).

Annual herb to 12 cm high with a cluster of 5–20 or more branches arising from the rootstock. *Leaves* confined to the very base of the branches in a loose rosette, those observable opposite, spathulate to narrow obovate, 30–60 mm long, 4–8 mm wide, flat, pale to mid green, glabrous, more or less fleshy *in vivo*, with a midvein apparent on the underside; basal pairs of leaves much shorter, broadly spathulate to obovate. *Flowers* 20 or more, in tight clusters in flower, spaced by fruiting stage, arranged singly in spiciform racemes terminating scapes *c.* 80–150 mm long emergent well above the leaves, the peduncle *c.* 65–130 mm long; bracts and bracteoles green with a broad white margin, erose to erosulate, glabrous; bracts ovate, (0.6–)0.8–1.2 mm long, the lowest up to 2.0 mm long; bracteoles 2, opposite, borne at the base of the pedicel, narrow ovate, 0.4–0.5 mm long; pedicels 0.1–0.2 mm long, lengthening to 0.3 mm long in fruit. *Hypanthium* cup-shaped, *c.* 0.5 mm long, 0.8–1.0 mm broad at apex, green, glabrous. *Sepals* ovate, 1.0–1.1 mm long, *c.* 0.5 mm broad, green, sometimes reddened towards apex, broadly acute to obtuse, with broadish white margin, erosulate towards the apex, glabrous. *Corolla* white, with tube 1.8–2.0 mm long, *c.* 0.6 mm broad; lobes flat, spreading at right angles to slightly reflexed, ovate to elliptic-ovate, (1.5–)1.8–2.1(–2.3) mm long, 0.9–1.4 mm broad, obtuse. *Stamens* 3, equal in length; anthers 0.6–0.7 mm long. *Ovary* 3-carpellate. *Cocci* 3, attached at very base to the gynophore, borne within the spreading, slightly accrescent, membranous fruiting hypanthium, broadly obovoid-obloid, 1.5–1.7 mm long, 1.3–1.4 mm broad, indistinctly rugose-reticulate, eglandular-asperate, light green to light brown; scar around point of attachment to the gynophore triangular, *c.* 0.5 mm long, 0.2 mm wide, convex, lacking a cartilaginous swelling; gynophore slightly swollen with cartilaginous tissue surrounding the short basal stalk and points of attachment of the cocci, with style much shorter than the coccus length and as long as the stigmas. (Figure 1)

Phenology. From available knowledge known to flower and fruit in October (type collection) and November with buds known in late August indicating that it flowers at least as early as September.

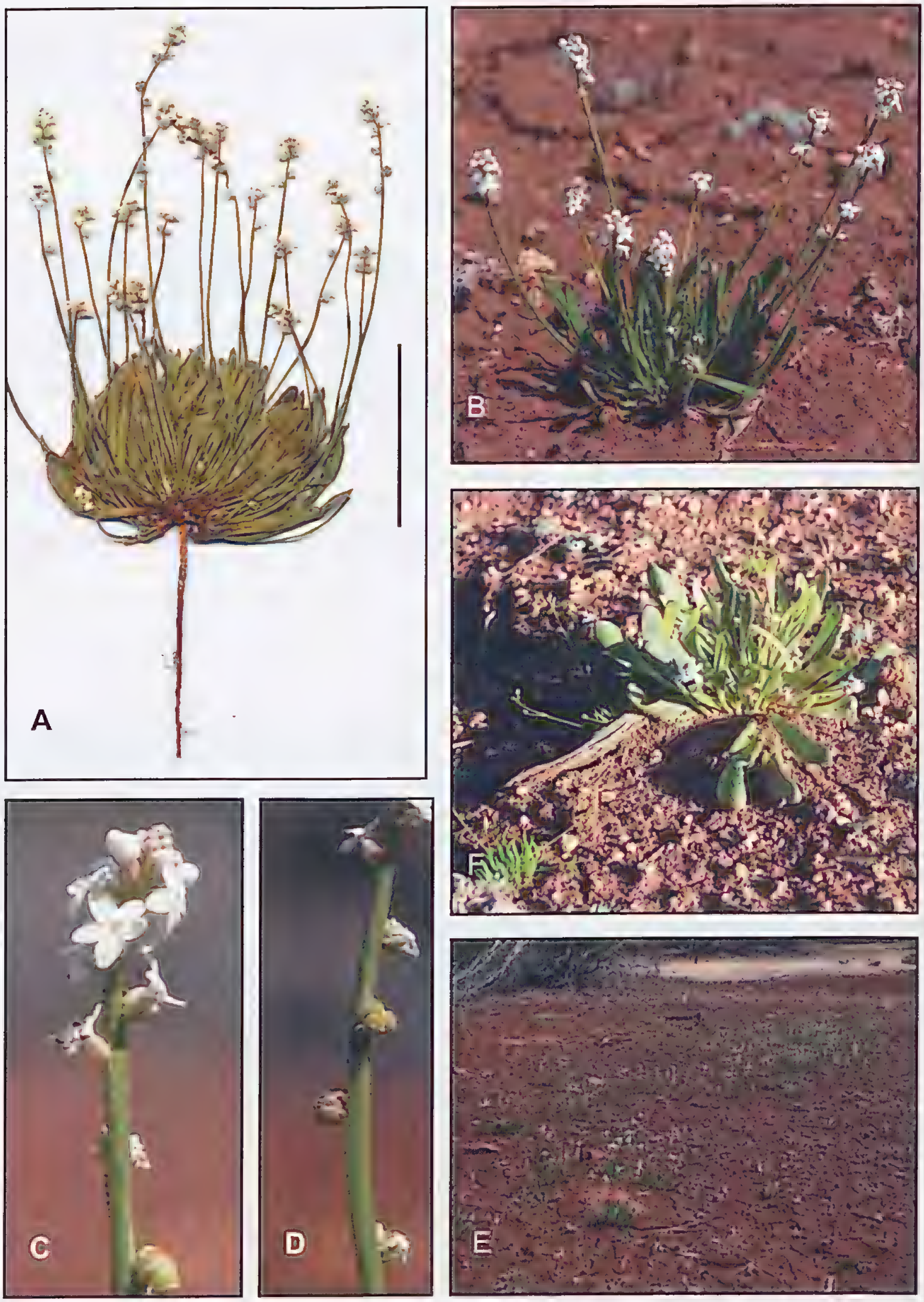

Figure 1. *Stackhousia stratfordii*, type population. A – from visit on 8th October 2009, scanned image of herbarium specimen (*G. Cockerton* LCH 26184), scale bar = 5 cm; B – E. Visit on 8th October 2009. B – whole plant; C – D – inflorescence with buds, flowers and fruits; E – population on smectite clay. F. Visit on 27th August 2003, young plant with flowering stems beginning to elongate. Photographs by G. Cockerton .

Distribution. Known only from the type locality approximately 50 km west of Norseman, Western Australia in the Coolgardie IBRA region, which comprises semiarid woodland and shrubland communities.

Habitat. At the type locality this species is restricted to a well-defined, boggy depression, estimated to be 1000 sq m in area, of dark brown smectite clay soil, on the crest of a ridge (Figures 1B, E). Soil is a friable self mulching yellowish-red clay. In 1997 80% of the ground was bare and a thick layer of leaf litter was restricted to under trees. Associated vegetation includes *Eucalyptus trichopoda, Eucalyptus calycogona* ssp. *calycogona* (dominant) and *Eucalyptus melanoxylon* woodland 4–7 m high, with a scattered shrub understorey of *Exocarpos aphyllus*, *Eremophila ionantha*, *Santalum acuminatum*, *Alyxia buxifolia*, *Grevillea acuaria* and *Eremophila dempsteri*. Other herbs present with the new species included species of Asteraceae, *Ptilotus aervoides, Ptilotus carlsonii, Hydrocotyle* sp. and *Goodenia* sp.

This small, specialised and confined habitat is surrounded by dark red sandy loams supporting *Eucalyptus griffithsii* woodlands with a *Triodia scariosa* understorey.

Conservation status. Given its very restricted known distribution, *Stackhousia stratfordii* has recently been listed as Priority One under the Department of Environment and Conservation (DEC) Conservation Codes for Western Australia Flora.

Etymology. Named in recognition of Ms Kirsty Stratford's major contribution to the botany of the Western Goldfields over many years. She and the second author discovered the species in 1997 and photographed it in 2003 when they brought it to the attention of the Western Australian Herbarium and the senior author.

Notes. The site is traversed by a grid line constructed for mining exploration prior to 1997, with the majority of the surrounding area undisturbed. There is no evidence of recent fires. At that time of its discovery it was suggested that the presence of the few plants of this geosporous species sighted were a response to disturbance caused by track construction activities. Observations in 2009, in the absence of any disturbance to the site in intervening years, indicate that the species is an annual responding to seasonal rainfall and is unlikely to be reliant on disturbance.

The first specimen of this new species was collected in 1997 (*G. Cockerton & K. Stratford* LCS 3685); however, despite a recent check it remains misplaced in the Western Australian Herbarium (Ms Karina Knight, pers. comm.). A duplicate in the Anaconda Nickel Ltd Reference Herbarium, also has been misplaced along with the whole herbarium (Andrew Clayton, pers. comm.). No collections were made in a visit in August 2003 as plants were immature.

Acknowledgments

This species was first located during vegetation surveys for Anaconda Nickel Ltd. Kevin Thiele, an anonymous referee and Kelly Shepherd are thanked for comments on the manuscript and support for its publication.

References

Barker, W.R. (1983). Stackhousiaceae. *In*: Morley, B. & Toelken H.R. (ed.) *Flowering plants in Australia*. pp. 224–226. (Rigby: Adelaide.)

Barker, W.R. (1984). Stackhousiaceae. *In*: *Flora of Australia.* Vol. 22, pp. 185–200, 203 (Australian Govt. Publishing Service: Canberra.)

Barker, W.R. (in press). Celastraceae subfam. Stackhousioideae: a conspectus, keys, typifications, and new taxa and combinations. *Journal of the Adelaide Botanic Gardens*.

Burge, D.O. & Barker, W.R. (2010). Evolution of nickel hyperaccumulation by *Stackhousia tryonii* (Celastraceae), a serpentinite-endemic plant from Queensland, Australia. *Australian Systematic Botany* 23: 415–430.

Hennig, W. (1966). [Davis, D & Zangerl, R. translation]. *Phylogenetic systematics*. (University of Illinois Press: Urbana, Ill.)

Kubitzki, K. (2004a). Introduction to the families treated in this volume. *In*: Kubitzki, K. (ed.). *The families and genera of vascular plants*. Vol. 6, pp. 1–11. (Springer-Verlag: Berlin.)

Kubitzki, K. (2004b). Lepidobotryaceae. *In*: Kubitzki, K. (ed.). *The families and genera of vascular plants.* Vol. 6, pp. 233–235. (Springer-Verlag: Berlin.)

Simmons, M.P. (2004a). Celastraceae. *In*: Kubitzki, K. (ed.). *The families and genera of vascular plants.* Vol. 6, pp. 29–64. (Springer-Verlag: Berlin.)

Simmons, M.P. (2004b). Parnassiaceae. *In*: Kubitzki, K. (ed.). *The families and genera of vascular plants.* Vol. 6, pp. 291–296. (Springer-Verlag: Berlin.)

Simmons, M.P., Cappa, J.J., Archer, R.H., Ford, A.J., Eichstedt, D. & Clevinger, C.C. (2008). Phylogeny of the Celastreae (Celastraceae) and the relationships of *Catha edulis* (qat) inferred from morphological characters and nuclear and plastid genes. *Molecular Phylogenetics and Evolution* 48: 745–747.

Zhang, L-B. & Simmons, M.P. (2006). Phylogeny and delimitation of the Celastrales inferred from nuclear and plastid genes. *Systematic Botany* 31: 122–137.

Nuytsia 21(2): 75–89 (2011)

New, locally endemic taxa in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from the Perth and midwest regions of Western Australia

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Abstract

Hislop, M. New, locally endemic taxa in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from the Perth and midwest regions of Western Australia. *Nuytsia* 21(2): 75–89. Four new taxa, *Leucopogon maritimus* Hislop, *L. nitidus* Hislop, *L. stokesii* Hislop, and *L. squarrosus* Benth. subsp. *trigynus* Hislop are described and mapped; the first three are illustrated. All have very restricted distributions and are of high conservation priority. Lectotypes for *L. squarrosus* and *L. brachycephalus* DC. var. *heterophyllus* Sond. are designated.

Introduction

With over 350 taxa in Western Australia's Southwest Botanical Province, the family Ericaceae (formerly segregated as Epacridaceae) is the fifth largest within a region that is globally recognised as a hotspot of botanical diversity (e.g. Myers *et al.* 2000). In common with Fabaceae, Myrtaceae and Proteaceae, the three dicot families with greater numbers in the SWBP, Ericaceae includes many narrow-range endemics (Hopper & Gioia 2004).

Ongoing taxonomic research into the three largest Western Australian genera within the family, *Leucopogon* R.Br., *Andersonia* R.Br. and *Astroloma* R.Br., indicates that all include significant numbers of undescribed taxa (*c.* 80, 20 & 10 respectively, are listed on *Florabase* in Western Australian Herbarium 1998–), many of which are regional or local endemics. The figure for *Leucopogon* includes members of both *Leucopogon s. str.* and of the several other taxonomic elements currently included in that genus. Of the more than 200 *Leucopogon* taxa (formal and informal names) now listed on the Census of Western Australian Plants, in the order of fifty percent are true *Leucopogons* and the balance will eventually need to be transferred to other genera. Quinn *et al.* (2003) presents the most recent published research dealing with the molecular phylogeny of *Styphelieae* which clearly demonstrates the polyphyletic status of *Leucopogon* as now constituted. Hislop & Chapman (2007) elucidate the morphological characters by which *Leucopogon s. str.* can be separated from the other elements currently included within that genus.

The primary purpose of this paper is to formally describe four locally endemic taxa of *Leucopogon s. str.* with high conservation priority.

Methods

This study was based on an examination of dried specimens housed at PERTH. The details of the methods used to measure plant parts and make other morphological observations are as described previously (Hislop 2009a). The inflorescence type of the species treated in this paper is of the kind described for the *Leucopogon gracilis* group (Hislop 2009b). The basal point of the terminal inflorescence for that species is therefore taken to be the lowest axil from which a single flower arises (below which multi-flowered axillary inflorescences are usually present), and for axillary inflorescences, the point of attachment to the main axis. The fertile bract measurements are taken from the upper three inflorescence nodes only.

The distribution map was compiled using DIVA-GIS Version 5.2.0.2 and based on PERTH specimen data.

Taxonomy

Leucopogon maritimus Hislop *sp. nov.*

Leucopogi squarroso subsp. *squarroso* affinis sed ovario 3(4)-loculari, sepalis minus acutis; a subsp. *trigyno* stylo breviore; ab ambobus foliis incurvis non recurvis, petiolo bene manifesto non sessili vel subsessili differt.

Typus: Wilbinga [north of Yanchep], Western Australia [precise locality withheld for conservation reasons], 2 May 2008, *M. Hislop* 3770 A (*holo*: PERTH 07970870; *iso*: CANB, K, MEL, NSW).

Leucopogon sp. Perth coastal (A.S. George 17305), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed June 2010]

Low, spreading *shrubs* to *c*. 40 cm high and 60 cm wide, often multi-stemmed close to the base but single-stemmed at ground level with a fire-sensitive rootstock. Young *branchlets* with a moderately dense to dense, ± dimorphic indumentum of patent, straight or somewhat decurved white hairs, the longer of which are 0.2–0.5 mm long, the shorter < 0.1 mm long, the indumentum persistent on the older stems, where it is present in longitudinal bands. *Leaves* spirally arranged, antrorse, usually steeply so, narrowly elliptic, 3.9–8.6 mm long, 1.2–2.6 mm wide; apex acute or subacute, without a differentiated callus point; base cuneate or attenuate; petiole moderately well-defined, cream or yellowish in colour, 0.3–0.6 mm long, glabrous on abaxial surface, sparsely hairy adaxially and with a few marginal hairs; lamina 0.15–0.20 mm thick, adaxially concave, incurved along the longitudinal axis; surfaces ± concolorous; adaxial surface usually rather shiny, glabrous or sparsely hairy towards the base, the venation indistinct; abaxial surface shiny, glabrous, usually striate with 5–7 raised primary veins, less often ± smooth, the midrib rather thicker than the other veins especially towards the apex; margins usually ciliate, often conspicuously so, with coarse antrorse or patent hairs, 0.05–0.50 mm long, occasionally ± glabrous. *Inflorescences* erect, terminal and upper-axillary, often aggregated into compact conflorescences; axis 3–7 mm long with 4–12 densely arranged flowers, terminating in a bud-like rudiment or an attenuate point; axis indumentum of dense, patent hairs 0.10–0.20 mm long; flowers erect and sessile. *Fertile bracts* narrowly ovate to ovate, 0.9–1.8 mm long, 0.7–0.9 mm wide, acute or subacute. *Bracteoles* ovate, 1.1–1.8 mm long, 0.8–1.1 mm wide, acute or subacute, keeled; abaxial surface glabrous throughout or with a few hairs about the upper keel, with broad scarious margins; adaxial surface shortly appressed hairy; margins glabrous or minutely ciliolate. *Sepals* ovate or narrowly ovate, 1.9–3.0 mm long, 0.9–1.2 mm wide, acute or subacute; abaxial surface glabrous, the central portion pale greenish or straw-coloured, sometimes faintly tinged pink, venation obscure apart from a slightly raised paler midrib, becoming scarious towards the margins; adaxial surface glabrous throughout or with a few appressed hairs towards the apex; the margins mostly glabrous, ciliolate only towards the apex with hairs 0.05–0.10 mm long. *Corolla tube* white, broadly campanulate, distinctly shorter than the sepals (by up to 1.3 mm), 0.8–1.2 mm long, 1.2–1.5 mm wide, glabrous externally and internally. *Corolla lobes* white, much longer than the tube (ratio = 1.9–2.8:1), widely spreading from the base and recurved, 1.9–2.8 mm long, 0.6–0.8 mm wide at the base, glabrous externally, densely bearded internally; indumentum white, 0.6–0.8 mm long near apex; glabrous tip very short *c.* 0.1 mm long. *Anthers* usually partially exserted from the tube (by 3/4–7/8 of their length), occasionally fully exserted, 0.9–1.5 mm long, prominently recurved at apex; sterile tips conspicuous, white, 0.2–0.3 mm long. *Filaments* terete, 0.5–0.7 mm long, attached *c.* 2/3 above anther base, adnate to tube just below sinus. *Ovary* broadly or depressed obovoid, 0.4–0.5 mm long, 0.5–0.6 mm wide, appressed-hairy in the lower half, 3(4)-locular. *Style* 0.25–0.40 mm long, well-differentiated from ovary apex, included within the corolla tube; *stigma* not or scarcely expanded; *nectary* annular, 0.20–0.35 mm long, entire or very shallowly lobed, glabrous. *Fruit* ellipsoid or ovoid, 1.3–1.8 mm long, 0.8–1.1 mm wide, distinctly shorter than the calyx, truncate with a narrow, undulate, apical or subapical rim, the surface between the rim and the style base flat or ascending gently, hairy in the lower 2/3 with a rather sparse antrorse-appressed indumentums, hairs 0.2–0.3 mm long, smooth beneath the hairs; style persistent. (Figure 1)

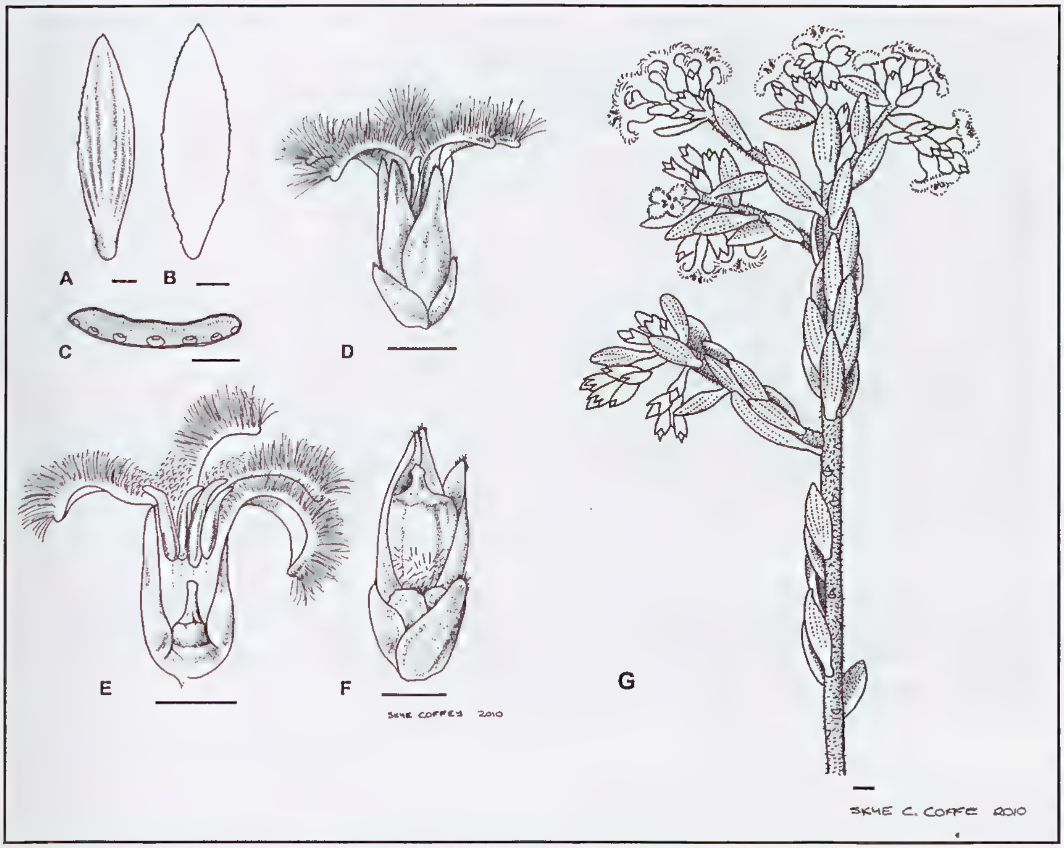

Figure 1. *Leucopogon maritimus*. A – leaf, abaxial surface; B – leaf, adaxial surface; C– leaf, section; D – flower; E– flower, longitudinal section; F – fruit; G – flowering branchlet. Scale bars: all = 1 mm. Drawn by Skye Coffey from *M. Hislop* 3769 (A–F), *M. Hislop* 3792 (G).

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 27 June 1966, *M.D. Barrow* 3592 (PERTH); 27 Nov. 1996, *A.S. George* 17305 (CANB, PERTH); 10 May 1998, *M. Hislop* 1040 (CANB, NSW, PERTH); 13 Apr. 2008, *M. Hislop* 3746 (CANB, NSW, PERTH); 13 Apr. 2008, *M. Hislop* 3747 (CANB, MEL, PERTH); 2 May 2008, *M. Hislop* 3769 (HO, MEL, PERTH); 2 May 2008, *M. Hislop* 3772 (CANB, NSW, PERTH); 3 Aug. 2008, *M. Hislop* 3792 (CANB, NSW, PERTH); 21 Aug. 2007, *K. McCreery et al.* TR 1–OPP03 (PERTH); 20 Oct. 2007, *K. McCreery* EGRd5–1 (PERTH); 8 Mar. 2002, *K. Richardson* KCR 31 (PERTH); 14 June 2007, *K. Richardson* KCR 368 (PERTH); 9 Aug. 1960, *G.G. Smith s.n.* (PERTH).

Distribution and habitat. Leucopogon maritimus is restricted to near-coastal Quindalup dunes, from a small area of coastline about 40–70 km north of Perth (Figure 2). It occurs in deep, calcareous sands, on the mid to upper slopes of dunes or in shallow sand over limestone, but avoiding the thicker vegetation of the swales. It grows in low heathland communities often dominated by *Melaleuca systena*, *Acanthocarpus preissii*, *Acacia lasiocarpa* and *Olearia axillaris*, sometimes in close proximity to the common coastal epacrids *Leucopogon parviflorus* and *L. insularis*.

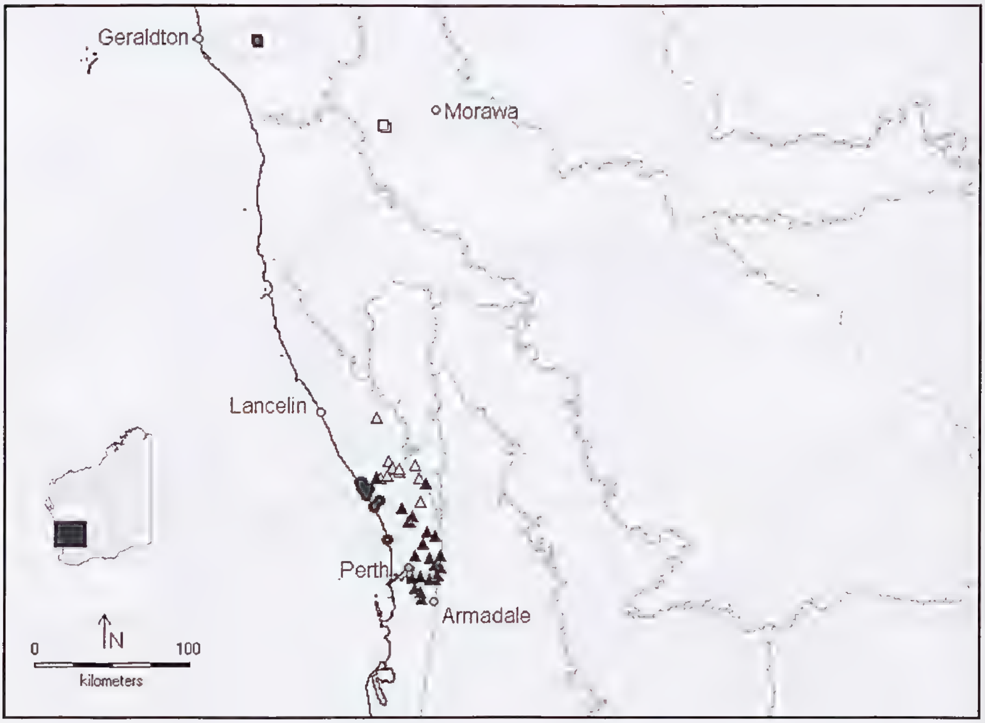

Figure 2. Distribution of *Leucopogon nitidus* (■), *L. stokesii* (□), *L. maritimus* (⊙), *L. squarrosus* subsp. *squarrosus* (▲) and *L. squarrosus* subsp. *trigynus* (△) in Western Australia.

Phenology. Flowering collections have been made between November and August, although in average seasonal conditions the peak is probably between April and June. Fruit is also likely to be present over many months but especially between June and September.

Etymology. From the Latin *maritimus* (by the sea), referring to the coastal distribution of this species.

Conservation status. Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora: Priority One (Smith 2010, as *L.* sp. Perth coastal (A.S. George 17305)). Although locally common, most of the known distribution of *L. maritimus* is in areas proposed for future residential development. The southernmost record (*M.D. Barrow* 3592) collected in the mid 1960's has the vague locality 'Burns – Mullaloo'. This area has now been largely cleared of native vegetation and the species is quite likely to have already disappeared from there. The northern limit of its range has yet to be ascertained, but a thorough search by the author in a large area of coastal heath to the immediate south of the Moore River estuary (*c.* 12 km N of the most northerly current record), was unsuccessful.

Affinities. *Leucopogon maritimus* appears to be closely allied to *L. squarrosus* Benth., a species which occurs primarily on the Bassendean Sands of the Swan Coastal Plain. The drupes of the two have a very similar shape and indumentum, and both have sepals much longer than the mature fruit. In addition they have numerous, short, densely-flowered inflorescences which are aggregated into compact conflorescences. However they are readily distinguished by consistent foliar differences. *Leucopogon squarrosus* has leaves which are variable in orientation (from steeply antrorse to retrorse often on the same plant) and shape (variously obovate, elliptic or occasionally ovate), and which are always more or less recurved along their longitudinal axis, with the lamina frequently ± stem-clasping in the lower half. By contrast in *L. maritimus* the leaves are consistently antrorse, usually steeply so, always narrowly elliptic, incurved along their longitudinal axis and never stem-clasping. The leaf bases in *L. squarrosus* are also very broad, with or without an obscure petiole, and usually occupy the entire width of the branchlet (excluding those on the main axes), whereas in *L. maritimus* the leaves are markedly narrowed towards the base, with the branchlet surface clearly visible on either side of a well-defined petiole. In addition *Leucopogon maritimus* has less acute sepals (relative to the typical subspecies of *L. squarrosus* only), which are generally shorter (1.9–3.0 mm long, but usually < 2.6 mm, compared to 2.5–3.6 mm long, usually > 2.8 mm in *L. squarrosus*), and shorter corolla tubes (0.8–1.2 mm long, cf. 1.0–1.8 mm in *L. squarrosus*). While the 3(4)-locular ovary of *Leucopogon maritimus* provides a further difference from the typical subspecies of *L. squarrosus* (2(–3)-locular), it is shared with subspecies *trigynus*. However, in addition to the foliar characters discussed above, these two can also be separated by style length: 0.25–0.40 mm long in *L. maritimus* compared to 0.50–0.70 mm in *L. squarrosus* subsp. *trigynus*.

Notes. Local endemism is rare in the flora of near-coastal, calcareous sands (Hopper & Gioia 2004), however other examples from the west coast of Western Australia are two recently described species, *Marianthus paralius* and *Hakea oligoneura*.

Leucopogon nitidus Hislop, *sp. nov.*

Leucopogi cinereo similis sed forma et indumento fructi differt in *L. nitido*; apice fructi plano vel ascendenti inter rimam et basim styli, pilis longis appressis praecipue in dimidio inferiore praesentibus; in *L. cinereo* apice fructi praeceps descendenti inter rimam et basim styli, pilis brevibus ad apicem restrictum; in *L. nitido* sepalis acutis vel subacutis non manifeste obtusis.

Typus: Kojarena [east of Geraldton], Western Australia [precise locality withheld for conservation reasons], 19 July 2008, *J. Brooker* 170 (*holo*: PERTH 07908024; *iso*: CANB, NSW).

Leucopogon sp. Kojarena (J. Brooker 232), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed June 2010]

Erect, open *shrubs* to 50 cm high and 50 cm wide; fire tolerance of the rootstock unknown although likely to be fire-sensitive. Young *branchlets* with a moderately dense to dense indumentum of patent, ± straight or somewhat decurved hairs, 0.05–0.10 mm long. *Leaves* usually spirally arranged, occasionally opposite on a minority of branchlets, steeply antrorse, linear or very narrowly elliptic, 3.2–8.3 mm long, 0.5–0.8 mm wide; apex obtuse; base attenuate; petiole indistinct, yellowish, 0.1–0.3 mm long, shortly hairy on adaxial surface and margins, glabrous abaxially; lamina 0.35–0.50 mm thick, flat towards the base, becoming ± trigonous in the upper half, straight or gently incurved along the longitudinal axis; surfaces ± concolorous, shiny; adaxial surface usually sparsely hairy, especially towards the base, the venation not evident; abaxial surface with two deep grooves, one each side of the broad midrib, apparently glabrous, although short hairs are sometimes evident deep within the grooves; margins coarsely ciliate with stiff, antrorse hairs 0.05–0.20 mm long. *Inflorescences* erect, terminal and upper-axillary; axis 2–5 mm long, with 3–8 flowers, terminating in a bud-like rudiment or an attenuate point; axis indumentum of moderately dense, patent hairs 0.08–0.12 mm long; flowers erect and sessile. *Fertile bracts* narrowly ovate, obtuse, 1.9–2.6 mm long and 0.5–0.7 mm wide. *Bracteoles* ovate or broadly ovate, 1.2–1.5 mm long, 0.9–1.1 mm wide, obtuse or subacute, keeled; abaxial surface glabrous, becoming scarious towards the margins; adaxial surface shortly hairy in central portion; margins ciliolate. *Sepals* ovate, 2.0–2.4 mm long, 1.1–1.2 mm wide, acute or subacute; abaxial surface glabrous, greenish, often with some reddish-purple tinges towards the apex, the midrib somewhat raised, paler, other venation obscure, becoming scarious towards the margins; adaxial surface appressed-hairy in the upper half; the margins ciliolate with hairs 0.1–0.2 mm long. *Corolla tube* white, broadly campanulate, distinctly shorter than sepals, 0.9–1.3 mm long, 1.1–1.4 mm wide, glabrous externally and internally. *Corolla lobes* white, much longer than the tube (ratio = 2.3–3.1:1), widely spreading from the base and recurved, 2.5–2.9 mm long, 0.8–1.0 mm wide at the base, glabrous externally, densely hairy internally; indumentum white, distinctly shorter towards the base, 0.8–0.9 mm long near apex; glabrous tip *c.* 0.2 mm long. *Anthers* partially exserted from the tube (by 3/4–7/8 of their length), 1.3–1.6 mm long, prominently recurved at apex; sterile tips moderately conspicuous, 0.3–0.4 mm long. *Filaments* terete, 0.6–0.7 mm long, attached *c.* 2/3 above anther base, adnate to tube just below the sinus. *Ovary* broadly obovoid, rather angular, 0.5–0.6 mm long, 0.5–0.6 mm wide, sparsely appressed-hairy in the lower half, 3-locular. *Style* 0.4–0.5 mm long, tapering evenly from ovary apex, included within the corolla tube; *stigma* not or scarcely expanded; *nectary* annular, 0.3–0.4 mm long, very shallowly lobed, glabrous. *Fruit* ± cylindrical, 2.1–2.3 mm long, 0.9–1.0 mm wide, slightly to distinctly longer than the calyx, with a well-defined, undulate, subapical rim, the surface between the rim and the style base either ± level or more frequently ascending gently, hairy in the lower half with a rather sparse, steeply antrorse or antrorse-appressed indumentum, smooth beneath the hairs; style persistent. (Figure 3)

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 11 July 2001, *J. Brooker* 232 (PERTH); 19 July 2008, *A. Chant* SEW 6 (PERTH).

Distribution and habitat. Apparently restricted to a small area east of Geraldton (Figure 2), where it grows on a hilltop in shallow sandy soil over laterite. The associated vegetation is heathland dominated by *Allocasuarina campestris*, *Banksia fraseri* var. *ashbyi* and *Hakea lissocarpha*.

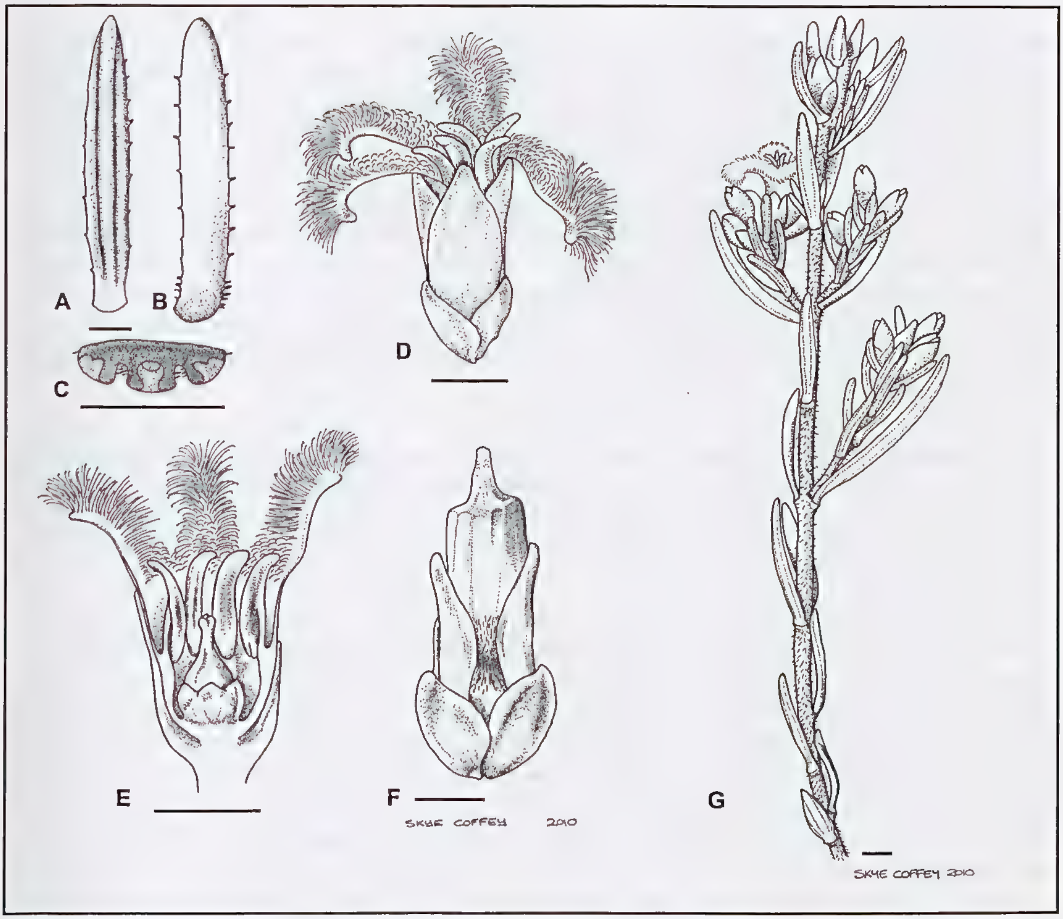

Figure 3. *Leucopogon nitidus*. A – leaf, abaxial surface; B – leaf, adaxial surface; C – leaf, section; D – flower; E – flower, longitudinal section; F – fruit; G – flowering branchlet Scale bars: all = 1 mm. Drawn by Skye Coffey from *J. Brooker* 170 (A–G).

Phenology. The three collections were made in July and all have flower buds, flowers and mature fruit present. This suggests that, in common with other species discussed under *Notes* below, it is likely to have a prolonged flowering period largely determined by soil moisture levels.

Etymology. The epithet is from the Latin *nitidus* (shining, bright), in reference to the glossy leaf surfaces.

Conservation status. DEC Conservation Codes for Western Australian Flora: Priority One (Smith 2010, as *L*. sp. Kojarena (J. Brooker 232)). Currently known only from a single hilltop in a long-established farming district, where it is said to be scattered and not common. In winter of 2008 the species was the subject of an unsuccessful search by local botanist Ann Gunness, while engaged in surveys (commissioned by the Department of Environment and Conservation) of a number of conservation-coded taxa in the Geraldton area.

Affinities. In terms of its foliar morphology, *Leucopogon nitidus* is remarkably similar to *L. cinereus* E. Pritz., apparently differing only in having shiny leaves which lack a glaucous texture or long spreading hairs, either or both of which are features of the latter species. It seems probable however that this similarity is the result of convergence, as the fruiting characters strongly suggest that the closest relatives of *L. nitidus* are members of a group of undescribed species which are widespread in the Geraldton Sandplains (refer under Notes below). In common with a number of other members of Group C (*sensu* Hislop & Chapman 2007), the drupe of *L. cinereus* terminates in a truncate and lobed rim beyond which the surface descends steeply to the style base (Figure 4). In *L. nitidus* by contrast, the rim is subterminal, more or less undulate, and with the surface flat or more usually ascending between the rim and style base. Although the drupe is hairy in both species, the indumentum type and distribution differ significantly. Whereas *L. nitidus* has long-appressed hairs on the lower surfaces of the drupe, *L. cinereus* has very short, patent hairs restricted to the fruit apex, between the rim and the style base. In addition to the differences in the fruit, *L. nitidus* has acute or subacute sepals (manifestly obtuse in *L. cinereus*) and a broad style base which tapers evenly from the ovary apex (cf. narrow and abruptly differentiated).

Notes. The presence, orientation and distribution of hairs on the drupes of *Leucopogon s. str.* is usually a reliable taxonomic character at the species level and also has some utility in subgeneric classification. For instance, whereas no species from Groups A or B (*sensu* Hislop & Chapman 2007), have an indumentum on their fruit, all but one in Group E have a hairy fruit and it is a diagnostic feature for a number of species in Group C.

Narrow fruit with a distinctive, long, antrorse-appressed indumentum is a feature *Leucopogon nitidus* has in common with the following five phrase-named taxa: *L.* sp. Watheroo (R.D. Royce 9616) (this taxon has until very recently been generally misidentified as *L. phyllostachys* Benth.), *L.* sp. Arrowsmith (M. Hislop 2509), *L.* sp. Cataby (F. Hort 1638), *L.* sp. Lesueur (B. Evans 530) and *L.* sp. South Eneabba (E.A. Griffin 8027). These taxa have largely parapatric distributions in the Geraldton sandplains between Cataby and Geraldton. The drupe apex is truncate and very similar to the members of Group C, although with a narrow and sometimes indistinct apical rim. Aside from the fruiting similarities the six taxa also have the following characters in common: more or less acute sepals, a 2- or 3-locular ovary and an unusually prolonged flowering period, which uncommonly in *Leucopogon s. str.* (especially in the Geraldton sand-plains), includes the summer–autumn period. Taken together, these shared characters suggest a close relationship. The wider affinities of this northern group however are rather problematic as aspects of their morphology could be regarded as intermediate between Groups C & D. This was the reason that *L. phyllostachys auct. non* Benth. (i.e. the taxon now referred to *Leucopogon* sp. Watheroo) and *L. squarrosus* (refer Notes under that species) were assigned only tentatively to Group D in Hislop & Chapman (2007). Recent examination of type material of *L. phyllostachys* has led to the realization that the name had been wrongly applied. The true *L. phyllostachys* is an apparently uncommon species from the Stirling Range, and is unequivocally a member of Group D.

Leucopogon squarrosus Benth. in Endlicher, S.F.L., Fenzl, E., Bentham, G. & Schott, H.W., *Enum. Pl.*: 77 (1837). *Styphelia squarrosa* (Benth.) F. Muell., *Fragm.* 6: 31 (1867). *Type*: Swan River Colony [near Perth, Western Australia], 27 November–19 December 1833, *C.A.A.F. von Hügel s.n.* (*lecto, here designated*: W 0004483, image seen; *isolecto*: K 000348476!).

Erect *shrub* to *c.* 150 cm high and 120 cm wide, but usually smaller, single-stemmed at ground level with a fire-sensitive rootstock. Young *branchlets* usually with a sparse to moderately dense, often rather irregular indumentum of patent, straight or somewhat decurved hairs, 0.05–0.20 mm long, occasionally ± glabrous. *Leaves* highly variable, spirally arranged, variously orientated, usually ± antrorse, but sometimes varying between steeply antrorse and ± retrorse on the same plant, variously obovate or elliptic, less often ovate, 2.2–8.2 mm long, 0.9–4.4 mm wide; apex acute, acuminate, subacute or obtuse; the base broad, cuneate or attenuate; petiole ± absent to *c.* 0.3 mm long; lamina 0.15–0.30 mm thick, varying from strongly concave or ± flat to slightly convex adaxially, the basal half often stem-clasping, longitudinal axis always recurved, often markedly so; surfaces discolorous or ± concolorous, matt or slightly shiny; adaxial surface glabrous or with a few hairs close to the base, venation not evident; abaxial surface usually somewhat paler, glabrous, with 5–9 primary veins which vary from ± flat to conspicuously raised, the midrib more prominent than the others, especially towards the apex; margins mostly glabrous throughout, occasionally minutely and irregularly ciliolate. *Inflorescences* erect, terminal and upper-axillary, often aggregated into dense conflorescences; axis 3–9 mm long with 5–14 densely arranged flowers, terminating in a bud-like rudiment or an attenuate point, the latter relatively long and conspicuous within the inflorescence; axis indumentum of moderately dense to dense patent hairs 0.1–0.3 mm long; flowers erect and sessile. *Fertile bracts* narrowly ovate, 1.7–2.4 long, 0.6–0.8 mm wide, acute or acuminate. *Bracteoles* narrowly ovate or ovate, 1.5–2.6 mm long, 0.8 –1.3 mm wide, acuminate or acute, sharply keeled; abaxial surface glabrous, apart sometimes for a few hairs about the keel apex, broadly scarious towards the margins; abaxial surface shortly hairy in central portion; margins glabrous in basal half, usually minutely ciliolate towards the apex. *Sepals* narrowly ovate, 2.5–3.6 mm long, 0.8–1.4 mm wide, acuminate, acute or subacute; abaxial surface usually glabrous or very shortly hairy, very occasionally with longer ± spreading hairs, the central portion pale greenish or straw-coloured, sometimes flushed pale pink, the midvein usually evident and often raised towards the apex, becoming scarious towards the margins; adaxial surface mostly glabrous but with a few inconspicuous short hairs in the upper half; margins glabrous in basal half, usually minutely ciliolate towards the apex. *Corolla tube* white, campanulate, or broadly campanulate, much shorter than the sepals (by up to 1.7 mm), 1.0–1.8 mm long, 0.8–1.5 mm wide, glabrous externally and internally. *Corolla lobes* white, much longer than the tube (ratio = 1.5–2.3:1), widely spreading from the base and recurved, 2.1–3.0 mm long, 0.5–0.7 mm wide at the base, glabrous externally, densely bearded internally; indumentum white, 0.8–1.0 mm long near apex; glabrous tip 0.2–0.3 mm long. *Anthers* partially exserted from the tube (by 2/3–3/4 of length), 1.0–1.9 mm long, prominently recurved at apex; sterile tips conspicuous, white 0.25–0.40 mm long. *Filaments* terete, attached 1/2–2/3 above anther base, 0.5–0.8 mm long, adnate to the tube just below the sinus. *Ovary* obovoid or depressed-obovoid, 0.4–0.5 mm long, 0.4–0.6 mm wide, appressed-hairy in the lower half, 2–3(4)-locular. *Style* 0.30–0.70 mm long, well-differentiated from the ovary apex, included within the corolla tube; *stigma* not or barely expanded; *nectary* annular, 0.20–0.40 mm long, ± truncate. *Fruit* ellipsoid or ovoid, 1.3–1.9 mm long, 0.8–1.1 mm wide, much shorter than the calyx, ± truncate, with an often rather indistinct apical or subapical rim, occasionally absent, the surface with a sparse to moderately dense indumentum of steeply antrorse hairs, 0.2–0.3 mm long, smooth beneath the hairs; style persistent.

Notes. The fruiting character of *Leucopogon squarrosus* and *L. maritimus* is very similar to that of the northern group of species discussed under *L. nitidus*, differing only in having a proportionally shorter and broader fruit which is always markedly shorter than the sepals. Other significant characters that this species-pair have in common with the northern group are the 2–3 locular ovary and acute sepals. Members of the northern group lack the conspicuously aggregated inflorescences seen in *L. squarrosus* and *L. maritimus*.

Two subspecies are recognised. They differ mainly in locule number and style length.

a. Leucopogon squarrosus Benth. subsp. squarrosus

Leucopogon squarrosus var. *paradoxus* Sond. in C. Lehmann, *Pl. Preiss.* 1: 318 (1845). *Type*: 'Herb. Preiss. No. 403 ex parte' (*holo*: ?LD, *n.v.*).

Leucopogon brachycephalus DC. var. *heterophyllus* Sond. in C. Lehmann, *Pl. Preiss.* 1: 308 (1845). *Type*: 'In limoso-calculosis ad radices jugi montium Darling's-range' [Western Australia], 15 Oct. 1839, *L. Preiss* 383 (*lecto, here designated*: MEL 75846!).

Shrubs to *c.* 70 cm high and 70 cm wide. *Leaves* variously obovate or elliptic, less often ovate, 2.2–5.0 mm long, 0.9–3.1 mm wide; apex usually acute or acuminate, occasionally subacute or ± obtuse. *Sepals* acuminate or acute. *Ovary* 2(–3)-locular. *Style* 0.3–0.5 mm long. (Figure 4)

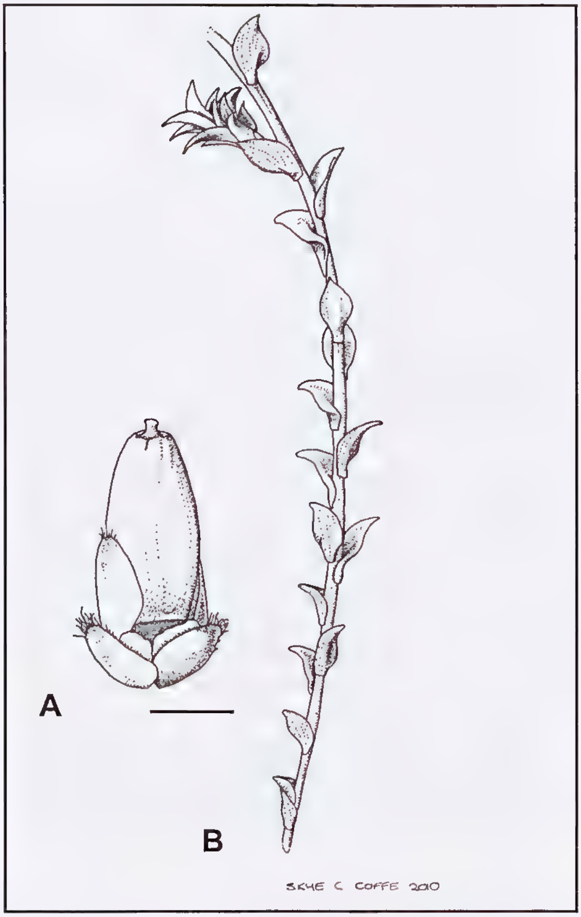

Figure 4. *Leucopogon cinereus*. A – fruit. *Leucopogon squarrosus* subsp. *squarrosus*. B – branchlet. Scale bars: both = 1 mm. Drawn by Skye Coffey from *M. Hislop* 3832 (A), *M. Hislop* 2128 (B).

Other specimens examined. WESTERN AUSTRALIA: Forrestfield Reserve, Forrestfield, Oct. 1967, *S.J.J. Davies* 4021 (PERTH); foot of Zig Zag [Road], Gooseberry Hill, 30 June 1961, *A.S. George* 2613 (PERTH); University of Western Australia, Botanic Reserve, bounded by Brook, Bickley and Boundary roads, Kenwick 1 Oct. 1992, *N. Gibson & M.N. Lyons* 1484 (PERTH); Redwood Rd NE of Yanchep, 1 Mar. 1966, *J. Havel* 258 (PERTH); remnant vegetation S of rubbish tip access Rd and W of Livingstone Rd, Canning Vale, 14 June 1997, *M. Hislop* 716 (PERTH); remnant bushland, adjacent Active Industries, N of Kenneth Rd, High Wycombe, 4 July 1999, *M. Hislop* 1323 (CANB, PERTH); Coastal Walk Trail, towards N boundary of Melaleuca Park, W of Bullsbrook, 17 Sep. 2000, *M. Hislop* 2128 (PERTH); northern end of Bush Forever Site 253, Jandakot Regional Park on W side of transmission line access track E of Warton Rd, Forrestdale, 16 Oct. 2003, *M. Hislop* 3068 (NSW, PERTH); Perry Rd Wanneroo, 8.5 km N of Chitty Rd, on E side of road, 8 Oct. 2002, *F. & J. Hort* 1862 (CANB, PERTH); along western boundary of Breera Road Nature Reserve, Gingin South, 4 Aug. 2008, *F. & J. Hort* 3220 (CANB, NSW, PERTH); Whiteman Park [N of Beechboro], 19 Oct. 1994, *B.J. Keighery* 2026 (PERTH); Talbot Road Reserve, Midland, 28 March 1992, *G.J. Keighery* 13780 (PERTH); Riverton, 18 July 1848, *Bro. Kissane* 23 (PERTH); Gnangara–Moore River State Forest, Melaleuca Block, 480 m W along unnamed firebreak from T junction on northern end of Buloke Rd, 120 m N of firebreak, 14.5 km SW of Bullsbrook GSS site PC6B, 19 Sep. 2008, *D.A. Mickle & M.L. Swinburn* 502 (PERTH); White Rd Plot 1, *c.* 120 m from Kelvin Rd, and 80 m from White Rd, Orange Grove, 19 July 2006, *J. Pryde & M. Hoskins* MM 7 (PERTH); Cannington, 19 Aug. 1948, *R.D. Royce* 2606 (PERTH); Upper Swan, 3 July 1918, *F.M.C. Schock* 338 (CANB, PERTH); north of Gnangara Rd, NE part of Lot 46 Maralla Rd, locality of Ellenbrook, 8 Aug. 1999, *M. & M. Trudgen* MET 20036 (CANB, PERTH).

Distribution and habitat. Restricted to the Swan Coastal Plain, from the southern suburbs of Perth near Forrestdale northwards to south-west of Gingin (Figure 2). Occurs on Bassendean Sands, mostly in low-lying situations, either as a component of the understory of *Banksia* woodland or in winter-damp heathland.

Conservation status. Much of the geographic range of this species lies within what is now the greater Perth metropolitan area and is consequently very fragmented, especially in the south. Although it doesn't currently fit criteria for inclusion on the DEC Conservation Priority list, the status of this species as a regional endemic in an area of rapid development should be given due consideration when assessing future clearing applications.

Notes. Although the locule number of the typical subspecies is consistently two in most specimens, very occasionally there is a mixture of 2- and 3-locular ovaries (e.g. *G.J. Keighery* 13780). Where this occurs, the other characters used here to separate between the subspecies, especially style length, are those of subsp. *squarrosus*.

Sonder (1845) recognised *Leucopogon squarrosus* var. *paradoxus* Sond. on the basis of minor differences in leaf shape and orientation. Such differences are common between and even within populations of many species of *Leucopogon* and *L. squarrosus* is particularly variable in its foliar morphology. The fact that the collection (*L. Preiss* 403) used by Sonder as the type of var. *paradoxus* has the same collecting number that he had previously cited under the typical variety, and therefore was very likely to be from the same gathering, suggests that the former merely represents infra-populational variation. However this remains to be confirmed as type material of var. *paradoxus* has not yet been located by the author.

Leucopogon brachycephalus var. *heterophyllus* Sond. is the typical subspecies of *L. squarrosus* but with unusually short leaves and sepals. The lectotype of the former designated here is from Sonder's own collection.

b. Leucopogon squarrosus Benth. subsp. **trigynus** Hislop *subsp. nov.*

A subspecie typico ovario 3(4)-loculari et stylo longiore differt.

Typus: Yeal Nature Reserve, west of Gingin, Western Australia [precise locality withheld for conservation reasons], 20 June 2010, *M. Hislop* 4039a (*holo*: PERTH 08227810; *iso*: CANB, MEL, NSW).

Shrubs to *c.* 150 cm high and 120 cm wide. *Leaves* obovate, often broadly so, 2.8–8.2 mm long, 1.7–4.4 mm wide; apex usually subacute or obtuse, less often acute. *Sepals* acute or subacute. *Ovary* 3(4)-locular. *Style* 0.5–0.7 mm long.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 15 July 1965, *J.C. Anway* 528 (PERTH); 1 Oct. 1932, *W.E. Blackall* 2972 (PERTH); 4 Aug. 1965, *S.J.J. Davies s.n.* (PERTH); 27 June 1980, *J. Dodd* 72 (PERTH); 22 July 1993, *N. Gibson & M.N. Lyons* 1321 (PERTH); 20 July 1993, *N. Gibson & M.N. Lyons* 1334 (PERTH); 29 Apr. 1966, *J. Havel* 269 (PERTH); 13 July 1966, *J. Havel* 292 (PERTH); 8 June 2010, *M. Hislop* 4036 (CANB, NSW, PERTH); 20 June 2010, *M. Hislop* 4040 (CANB, NSW, PERTH); 28 Oct. 1993, *B.J. Keighery & N. Gibson* 160 (PERTH); 11 June 1962, *F.G. Smith* 1662 (PERTH); July 1939, *Miss Tape s.n.* (PERTH).

Conservation status. Recently listed under DEC Conservation Codes for Western Australian Flora as Priority Two. Apparently restricted to a small part of the Swan Coastal Plain. Recent collections have all been from an area to the west and south-west of Gingin where it is locally common in the Yeal Nature Reserve. There are two old specimens with the vague localities of 'Jurien Bay Road' (*Miss Tape s.n.*) and 'Moore River' (*F.G. Smith* 1662). An effort by the author to find the taxon in apparently suitable habitat at the southern end of Moore River National Park was unsuccessful.

Notes. Although no mention is made of locule number or style length, Wheeler (1987) appears to refer, at least in part, to this taxon when she makes note after her treatment of *L. squarrosus* of 'a variant from between Upper Swan and Moore River [which] has larger, more erect and less squarrose leaves often with a broad, stem-clasping base [and which] often [has] less acute sepals'.

The distributions of the two subspecies approach each other very closely in an area south-west of Gingin and it appears that they may be narrowly sympatric. In this regard two collections made along the same track (Redwood Rd, NE of Yanchep) in 1966 are of particular interest. One of these (*J. Havel* 258) is the typical subspecies, collected in early March, the second (*J. Havel* 292) is subsp. *trigynus* and was collected in mid July. It is not known how close to one another these collections were made as no distances were given, but the track is about twelve kilometres long. The two collections have all of the diagnostic features of their respective subspecies.

Leucopogon stokesii Hislop, *sp. nov.*

A *Leucopogi pulchello* facie subtus folii plana non carinata, ovario 3–4- vice 4–5 loculari, apice fructi plano vel ascendenti inter rimam et basim styli vice praeceps descendenti differt.

Typus: north-east of Arrino Western Australia [precise locality withheld for conservation reasons], 9 August 2009, *M. Hislop & J. Borger* MH 3905 (*holo*: PERTH 08130868; *iso*: CANB, NSW).

Leucopogon sp. Dudawa (M. Hislop & J. Borger MH 3829), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed June 2010]

Erect, open *shrubs* to *c.* 160 cm high and 150 cm wide, single-stemmed at ground level with a fire-sensitive rootstock. Young *branchlets* with a sparse to moderately dense indumentum of straight or slightly decurved, patent hairs, 0.05–0.2 mm long. *Leaves* spirally arranged, steeply antrorse, narrowly elliptic, 3.2–7.2 mm long, 0.8–1.8 mm wide; apex obtuse; base attenuate or rarely cuneate; petiole usually well-defined, creamy-yellow to pale brown, 0.4–1.1 mm long, glabrous; lamina 0.3–0.4 mm thick, adaxially concave, gently incurved along the longitudinal axis; surfaces glabrous, markedly discolorous; adaxial surface dull, glaucous, the venation not evident; abaxial surface darker, shiny, ± smooth, the venation indistinct with 3–5 primary veins faintly discernible; margins glabrous or sparsely ciliolate with coarse hairs to 0.5 mm long. *Inflorescences* erect, mostly terminal with little upper-axillary development; axis 3–7 mm long, with 5–10 rather densely arranged flowers, terminating in a bud-like rudiment; axis indumentum of moderately dense hairs, mostly *c.* 0.05 mm long; flowers erect and sessile. *Fertile bracts* narrowly ovate, 1.4–3.1 mm long, 0.7–0.9 mm wide, obtuse. *Bracteoles* ovate or broadly ovate, 1.2–1.5 mm long, 0.9–1.2 mm wide, obtuse, keeled, although sometimes rather obscurely so; abaxial surface glabrous, apart from a few short hairs at the apex, becoming scarious towards the margins; adaxial surface sparsely and minutely hairy; margins ciliolate. *Sepals* ovate, 2.0–2.9 mm long, 1.0–1.5 mm wide, obtuse; abaxial surface glabrous, greenish in the central portion, often suffused purple towards the apex and in a submarginal band, becoming scarious towards the margins, the venation obscure apart from the pale midrib; adaxial surface sparsely and minutely hairy; margins minutely ciliolate with hairs to *c.* 0.08 mm long. *Corolla tube* white, campanulate or broadly campanulate, shorter than the sepals, 1.3–1.8 mm long, 1.3–1.5 mm wide, glabrous externally and internally. *Corolla lobes* white, usually flushed pink in the upper half, much longer than the tube (ratio = 1.5–2.3:1), widely spreading from the base and recurved, 2.4–3.0 mm long, 0.7–1.0 mm wide at the base, glabrous externally, densely bearded internally; indumentum white, 0.7–1.2 mm long near apex; glabrous tip 0.1–0.2 mm long. *Anthers* partially exserted from the tube (by 2/3–3/4 of their length), 1.4–2.0 mm long, recurved towards apex; sterile tips conspicuous, white, 0.4–0.7 mm long. *Filaments* terete, 0.7–0.9 mm long, attached *c.* 2/3 above anther base, adnate to the tube just below the sinus. *Ovary* broadly ellipsoid to broadly obovoid, 0.5–0.6 mm long, 0.5–0.6 mm wide, glabrous, 3–4(5)-locular. *Style* 0.4–0.7 mm long, tapering smoothly from a broad base, included within the corolla tube; *stigma* not or barely expanded; *nectary* annular, 0.25–0.40 mm long, entire or shallowly lobed for up to 1/4 of its length, glabrous. *Fruit* oblongoid or ellipsoid, glabrous, smooth, 1.8–2.5 mm long, 1.1–1.3 mm wide, longer than the calyx, bluntly angular in transverse section, with a moderately well-defined, subapical rim, the surface between the rim and the style base flat or ascending gently; style persistent. (Figure 5)

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 25 Sep. 2009, *J. Borger* DS 259-6 (CANB, PERTH); 10 Sep. 2008, *M. Hislop & J. Borger* MH 3829 (CANB, NSW, PERTH); 9 Aug. 2009, *M. Hislop & J. Borger* MH 3899 (CANB, MEL, NSW, PERTH).

Distribution and habitat. Known only from a small area north-east of Three Springs (Figure 2). The species occurs on and immediately below breakaways in rocky, grey loam over sandstone, where it grows in dense heath, usually dominated by *Melaleuca* spp.

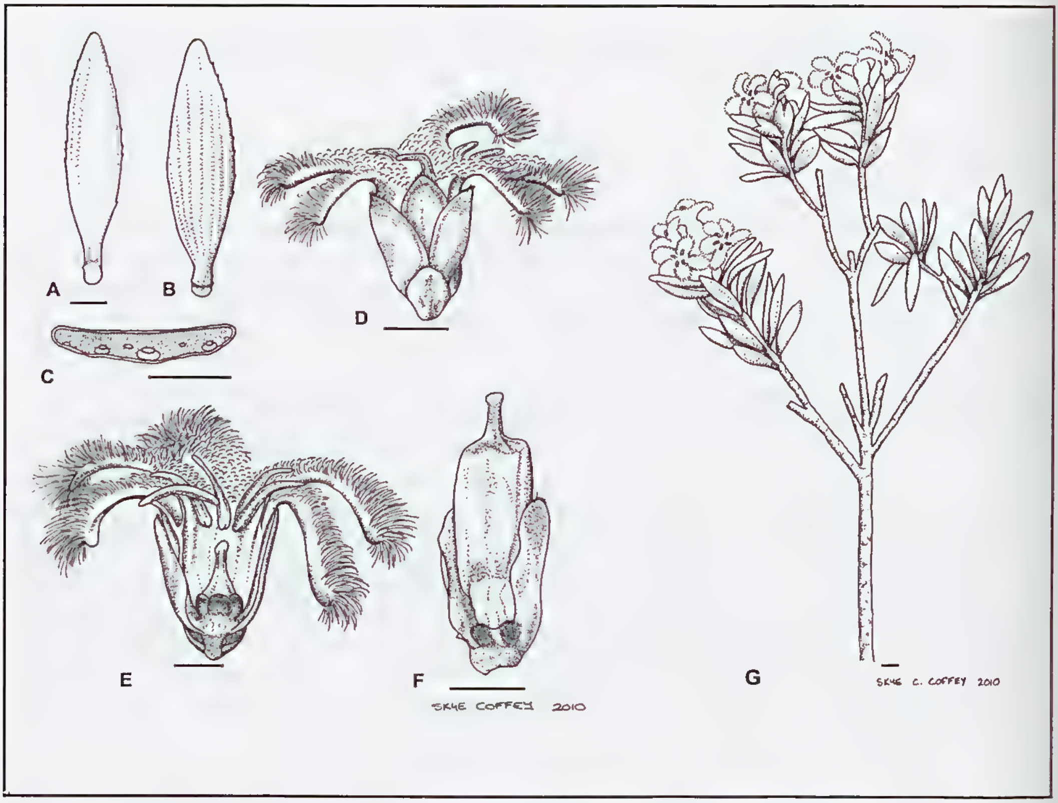

Figure 5. *Leucopogon stokesii.* A – leaf, adaxial surface; B – leaf, abaxial surface; C – leaf, section; D – flower; E – flower, longitudinal section; F – fruit; G – flowering branchlet. Scale bars: all = 1 mm. Drawn by Skye Coffey from *M. Hislop & J. Borger* MH 3905 (A–F), *J. Borger* DS 259-6 (G).

Phenology. Flowers between July and September. Mature fruit has been collected in the second half of September but is probably present from late August at least until early October.

Etymology. The specific name honours Dennis Stokes, farmer and naturalist, on whose property this species occurs, and who has made considerable efforts towards the conservation of what are undoubtedly some of the most interesting and valuable tracts of natural vegetation in the district.

Conservation status. DEC Conservation Codes for Western Australian Flora: Priority One (Smith 2010, as *L.* sp.Dudawa (M. Hislop & J. Borger MH 3829)). The only known populations are from a large system of breakaways on private property. The surface geology here is a locally uncommon sandstone of the Nangetty Formation (Baxter & Lipple 1985). Other breakaways in the general area have either been cleared, subject to intensive grazing or are of a different geology. Because of what appear to be very specific habitat requirements in an area heavily cleared for agriculture, the potential for the discovery of additional populations of this species seems limited.

Affinities. While floral and fruiting characters place *Leucopogon stokesii* in Group C (*sensu* Hislop & Chapman 2007), its close affinities are not obvious, and it is unlikely to be confused with any other species from the Midwest or indeed the Geraldton sand-plains as a whole. In gross morphology it somewhat resembles *L. pulchellus* Sond., a variable species which, in the broad sense, occurs from the northern Darling Range to the far south-west corner of Western Australia. Aside from the geographical disjunction it can be readily separated from *L. pulchellus* by a comparison of the abaxial leaf surfaces, which in the latter are prominently keeled towards the apex, whereas in *L. stokesii* they are smoothly concave throughout. Additionally the ovary locule number in *L. pulchellus* is usually 5, occasionally 4 (usually 3 or 4 in *L. stokesii*, occasionally 5), and the surface of the fruit apex descends steeply to the style base (cf. flat or gently ascending).

Notes. *Leucopogon stokesii* shows surprising floral variation within its very restricted distribution. The relatively wide range, for example, in the lengths of the style, sepals and corolla hairs are of a magnitude that might be expected of a widespread species rather than a local endemic. And while there is variation in locule number among some members of Group C, it is uncommon for species of *Leucopogon s. str.* generally to have a locule number which varies by more than one. For example those species which usually have a three locular ovary may sometimes also have four locules, but it is unusual for them to have five. Similarly those with a standard 5-locular ovary not uncommonly also have flowers with four locules, but rarely three. Again this degree of variation is otherwise only occasionally encountered in widespread species, such as *L. sprengelioides* Sond.

Acknowledgements

I would like to thank the following people for assisting in various ways in the preparation of this paper: Jenny Borger of WWF Australia for making a special effort to collect fruiting material of *Leucopogon stokesii* and to look for new populations of that species, Jenna Brooker for arranging a special trip in order to collect a type for *L. nitidus*, Skye Coffey for the illustrations and technical support, Juliet Wege for providing the distribution maps and Paul Wilson for the Latin diagnoses.

References

Baxter, J.L. & Lipple, S.L. (1985). *Perenjori, Western Australia.* (Geological Survey of Western Australia: Perth.)

Hislop, M. & Chapman, A.R. (2007). Three new and geographically restricted species of *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from south-west Western Australia. *Nuytsia* 17: 165–184.

Hislop, M. (2009a). The taxonomy of *Leucopogon bossiaea* and allied species (Ericaceae: Styphelioideae: Styphelieae) from the central south coast of Western Australia. *Nuytsia* 19: 17–35.

Hislop. M. (2009b). New taxa in the *Leucopogon gracilis* group (Ericaceae: Styphelioideae: Styphelieae). *Nuytsia* 19: 211–228

Hopper, S.D. & Gioia, P. (2004). The southwest Australian floristic region: evolution and conservation of a global hot spot of biodiversity. *Annual Review of Ecology, Evolution and Systematics* 35: 623–650.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B. & Kent, J. (2000). Biodiversity hotspots for conservation priorities. *Nature* 403: 853–858.

Quinn, C.J., Crayn, D.M., Heslewood, M.M., Brown, E.A. & Gadek, P.A. (2003). A molecular estimate of the phylogeny of Styphelieae (Ericaceae). *Australian Systematic Botany* 16: 581–594.

Smith, M.G. (2010). Declared Rare and Priority Flora List for Western Australia. (Department of Environment and Conservation: Kensington, WA.)

Sonder, O.G. (1845). Epacrideae. *In*: Lehmann, C. (ed.) *Plantae Preissianae* Vol.1. (Meissneri: Hamburg.)

Western Australian Herbarium (1998–). *FloraBase – The Western Australian Flora.* Department of Environment and Conservation. http://florabase.dec.wa.gov.au/ [accessed June 2010]

Wheeler, J.R. (1987). Epacridaceae. *In*: Marchant, N.G., Wheeler, J.R., Rye, B.L., Bennett, E.M., Lander, N.S., Macfarlane, T.D. *Flora of the Perth Region* Part 1. pp 172–196. (Western Australian Herbarium, Department of Agriculture: South Perth.)

Labichea rossii (Fabaceae: Caesalpinioideae), a new species from the Yilgarn Ranges, Western Australia

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Abstract

Gibson, N. *Labichea rossii* (Fabaceae: Caesalpinioideae), a new species from the Yilgarn Ranges, Western Australia. *Nuytsia* 21(3): 91–95 (2011). A new rare species of *Labichea* Gaudich. ex DC. is described from a ridge of Banded Iron Formation in the ranges near Mt Holland. Unlike most species in the genus, this new species, *L. rossii* N.Gibson, has very dissimilar petals more reminiscent of flowers from subfamily Faboideae.

Introduction

Labichea Gaudich. ex DC. currently comprises 14 species, of which eight occur in Western Australia, one in the Northern Territory, and five in Queensland (Ross 1985). Two of the Western Australian species are only known from their type locations. The genus was revised by Ross (1985) and subsequently appeared in Volume 12 of the *Flora of Australia* (Ross 1998).

In recent years considerable survey effort has been focused on the Banded Iron Formation and greenstone ranges of the Yilgarn Craton (Gibson *et al.* 2007). This has resulted in the recognition and description of 21 taxa restricted to, or with their distributions centred on, these ranges (Wege *et al.* 2007). A new species of *Labichea* was found in the most recent of these surveys in the northern Forrestania Greenstone Belt near Mt Holland along with two other apparently undescribed taxa (Thompson & Allen, in review). The *Labichea* collections from this area are unifoliolate and have clearly differentiated wing, standard and keel petals, unlike the previously described species.

Taxonomy

Labichea rossii N.Gibson, *sp. nov.*

Species nova *L. punctata* Benth. affinis, sed floribus brevioribus et petalis dissimilis et ovario sericeis absentibus differt.

Typus: vicinity of Mt Holland, Western Australia [precise locality withheld for conservation reasons], 30 September 2010, *N. Gibson* 4686 & *E.M. Sandiford* (*holo*: PERTH 08259712; *iso*: BRI, CANB, MEL).

Labichea sp. Mt. Holland (W.A. Thompson & J. Allen 949), Western Australian Herbarium, in *Florabase*, http://florabase.dec.wa.gov.au [accessed August 2011].

Subshrub to 40 cm high, stems sparingly branched, semi-erect, clothed with appressed uncinate hairs and with occasional longer spreading hairs. *Leaves* unifoliolate, lamina narrowly elliptic, 25–35(–45) mm long, 5–7 mm wide, pungent apically, reticulate, with scattered tubercular-based uncinate hairs above, and with scattered appressed uncinate hairs below especially on midrib and leaf margins; petiole to 1 mm long, finely sulcate adaxially. *Stipules* narrowly triangular or subulate, 1.5–2.5 × 0.6–1 mm, glabrous, caducous. *Inflorescence* a 3–5-flowered raceme, much shorter than the subtending leaf; bracts ovate, (2.5–)3–4.5 × 2–2.5 mm, caducous. *Pedicels* 2–3 mm long, densely clothed with uncinated hairs. *Sepals* 5, becoming reflexed, the three outer ones 4–5 × 1.5–2 mm, acute apically, slightly cucullata, sparingly to densely clothed with uncinate hairs, the two inner sepals slightly shorter, almost glabrous with obtuse apex. *Petals* 4, yellow, dissimilar, wing petals 4–5 × 3–4 mm, standard 2.5–3 × 1.8–2 mm, keel 2.5–2.8 × 0.7–1 mm. *Stamens* 2, ± equal in length; filaments 0.3–0.5 mm long; anthers 2.8–3.5 mm long. *Ovary* 1–1.8 mm long, with a moderate to dense cover of uncinate hairs. *Style* 1.5–2.5 mm long. *Pods* not seen.

Other specimens examined. WESTERN AUSTRALIA: [precise locality withheld for conservation reasons] Forrestania Greenstone Belt (Mt Holland area), 4 Oct. 2009, *W.A. Thompson & J. Allen* 949 (PERTH).

Distribution. Currently only known from one small ironstone ridge, less than one hectare in area, near Mt Holland (Figure 1).

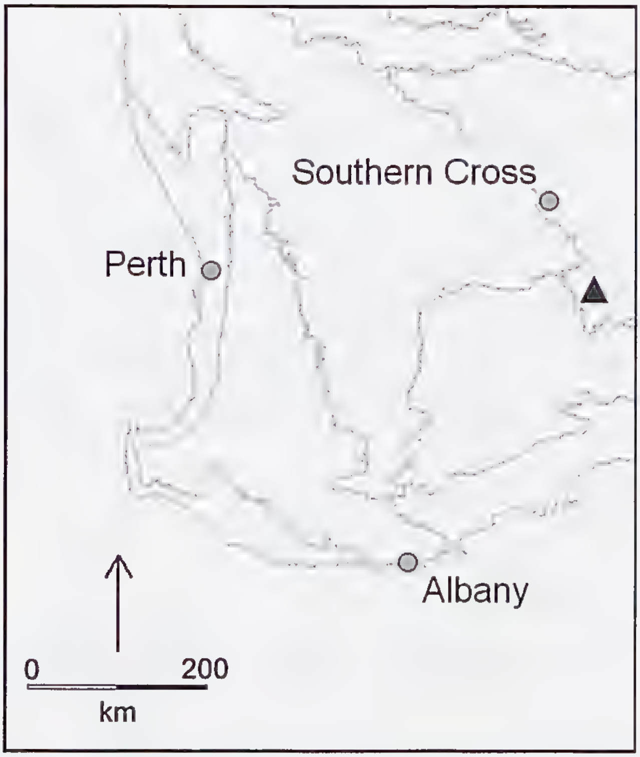

Figure 1. Distribution of *Labichea rossii* (▲) in south-west Western Australia. IBRA Bioregion boundaries (Department of the Environment, Water, Heritage and the Arts 2008) are shown in grey.

Habitat. The type location is on a small ironstone ridge which is dominated by an *Allocasuarina*-Proteaceae-Myrtaceae shrubland with occasional emergent eucalypts. *Labichea rossii* grows out of cracks in the massive outcropping banded ironstone, often in the shade of larger shrubs (Figure 2). The characteristic associated species include *Eucalyptus horistes, Allocasuarina acutivalvis* subsp. *acutivalvis, A. campestris, Banksia purdieana, Calothamnus quadrifidus* subsp. *seminudus, Hakea subsulcata, Melaleuca cordata,* and *Hibbertia exasperata.*

Phenology. Flowers in late September and early October.

Conservation status. *Labichea rossii* was recently listed as Priority One under the Department of Environment and Conservation (DEC) Conservation Codes for the Western Australian Flora. It is only known from the type location where it is locally common. The population is estimated to comprise approximately 100 plants. Despite extensive fieldwork being undertaken in the area over a two week period, no further populations were located. The two closest outcrops of Banded Iron Formation occur on Mt Holland and North Ironcap. No *Labichea* was found on Mt Holland while *Labichea stellata* J.H.Ross was found in similar habitats on North Ironcap. Both of these outcrops are less than 5 km from the *L. rossii* site.

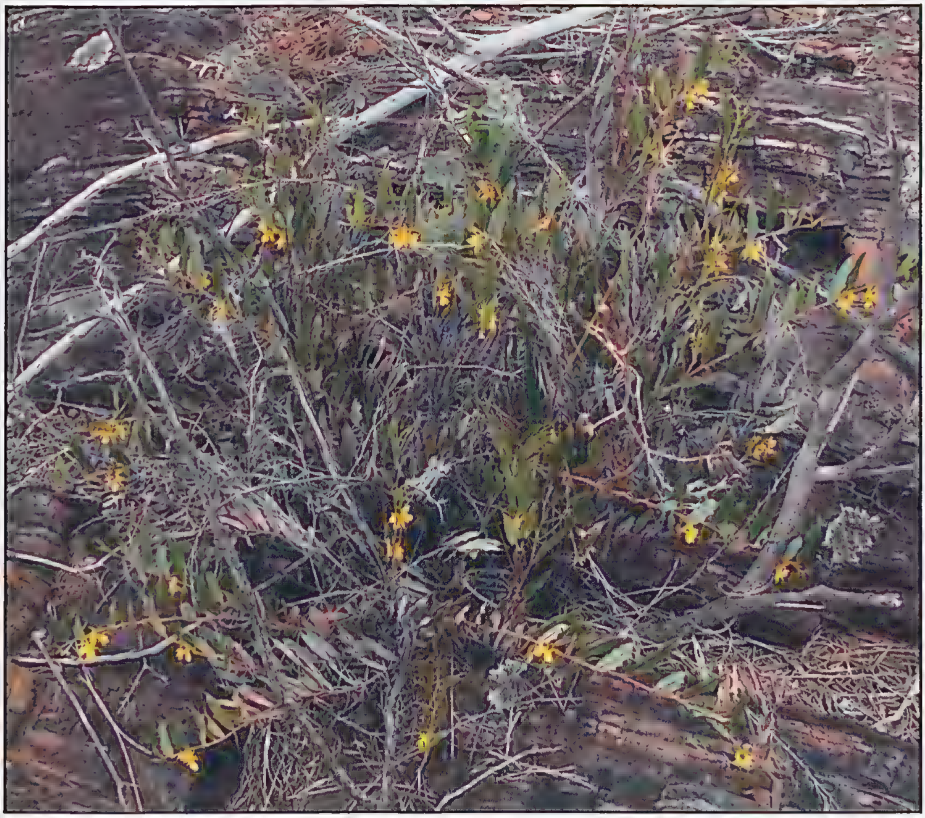

Figure 2. *Labichea rossii* growing out of cracks in massive ironstone on a small Banded Iron Formation ridge near Mount Holland. The dying back of some of the branches is probably due to the below average winter rainfall in 2010.

Etymology. Named in honour of Jim Ross, the recently retired head of the National Herbarium of Victoria (MEL), who has made a significant contribution to our understanding of the Fabaceae in Western Australia and who offered his unfailing assistance to Western Australian botanists during his stewardship at MEL.

Affinities and notes. Labichea rossii belongs to the small group of four taxa (*L. punctata* Benth., *L. rupestris* Benth., *L. digitata* Benth., and *L. stellata*) that possess equal anthers. It shows some affinities to the other unifoliolate taxon in this group *L. punctata,* which Ross (1985) considered to occupy an isolated position in the genus. However, *L. rossii* is easily separated from *L. punctata* by its smaller inflorescence and flowers, the lack of a silky indumentum on its ovary and its clearly differentiated wing, standard and keel petals (Figure 3). The unequal petals are more reminiscent of subfamily Faboideae than subfamily Caesalpinioideae and were consistent in all material studied. Of the 14 other species only the 5-foliolate *L. stellata* is reported as having unequal petals (Ross 1985). Some collections in PERTH of *L. stellata* (e.g. *P.S. Short* 1700a, 1700b*; N. Gibson & K. Brown* 3737) exhibit clearly differentiated petals similar to those of *L. rossii* while other collections have largely undifferentiated petals (e.g. *R.D. Royce s.n.* 8 Oct. 1965). All collections of *L. stellata* from the Mt Holland area have markedly dissimilar petals but this form is not restricted to this area. *Labichea rossii* is clearly differentiated from *L. stellata* by its unifoliolate leaves, shorter status (to 40 cm), lack of spreading hairs on young branchlets, and by its racemes being shorter than the subtending leaf.

Labichea rossii, *L. deserticola* J.H.Ross and *L. obtrullata* J.H.Ross have the most restricted distributions reported for the genus with *L. deserticola* (currently listed as Priority One, Smith 2010) only known from the type collection of Helms collected in 1891 from the Great Victoria Desert, and *L. obtrullata* (also listed as Priority One, Smith 2010) only known from two collections on Gabyon Station near Yalgoo made in 1962 and 1963 (Ross 1985, 1998). All three taxa urgently need further survey work to accurately determine their conservation status.

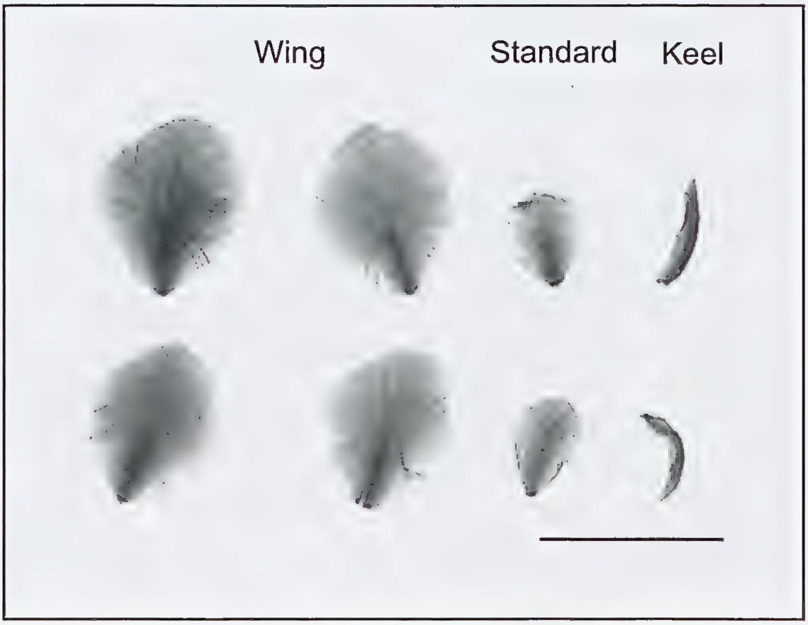

Figure 3. Dissected flowers of *Labichea rossii* showing clearly differentiated wing, standard and keel petals which are unusual in this subfamily (both from *N. Gibson* 4686 & *E.M. Sandiford*). Scale bar 5 mm.

Acknowledgments

I would like to acknowledge Wendy Thompson and Jessica Allen for bringing this species to my attention and Jim Ross for his comments on their collection. I also thank Paul Wilson who kindly corrected the Latin diagnosis and Kelly Shepherd for her skill in image processing.

References

Department of the Environment, Water, Heritage and the Arts (2008). *Interim Biogeographic Regionalisation for Australia (IBRA), Version 6.1.* http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html [accessed 8 May 2008]

Gibson, N., Coates, D.J., Thiele, K.R. (2007). Taxonomic research and the conservation status of flora in the Yilgarn banded iron formation ranges. *Nuytsia* 17: 1–12.

Ross, J.H. (1985). A revision of the genus *Labichea* Gaudich. ex DC. (Caesalpiniaceae). *Muelleria* 6: 23–49.

Ross, J.H. (1998). *Labichea. In*: *Flora of Australia.* Vol. 12, pp. 146–157. (CSIRO Publishing: Collingwood. Vic.)

Smith, M.G. (2010). *Declared Rare and Priority Flora List for Western Australia.* (Department of Environment and Conservation: Kensington, Kensington, WA.)

Thompson, W.A. & Allen, J. (in review) *Flora and vegetation of greenstone formations of the Yilgarn Craton: the northern Forrestania Greenstone Belt* [*Mt. Holland area*].

Wege, J.A., Shepherd, K.A. & Butcher, R. (2007). Preface. *Nuytsia* 17.

A new and rare species of *Ptilotus* (Amaranthaceae) from a suburban wetland of the eastern Swan Coastal Plain, Western Australia

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Abstract

Davis, R.W. & Tauss, C. A new and rare species of *Ptilotus* (Amaranthaceae) from a suburban wetland of the eastern Swan Coastal Plain, Western Australia. *Nuytsia* 21(3): 97–102. *Ptilotus christineae* R.W.Davis & Tauss, currently known from only one small population in the Greater Brixton Street Wetlands, about 14 km from the centre of the city of Perth, is described and illustrated. A key to *Ptilotus* R.Br. of the Swan Coastal Plain Biogeographical Region is provided.

Introduction

The Eremaean Botanical Province of Western Australia is the centre of diversity for *Ptilotus* R.Br., a large and almost exclusively Australian genus (Townsend 1993; Western Australian Herbarium 1998–). Only thirteen *Ptilotus* taxa (about 10% of those known from Western Australia) occur in the Swan Coastal Plain Biogeographical Region (SCP; Department of Environment, Water, Heritage and the Arts 2008). Two of the SCP taxa, *Ptilotus christineae* R.W.Davis & Tauss, described herein, and *P. sericostachyus* subsp. *roseus* (Moq.) Benl, are endemic to this region; both are helophytes that have only been recorded from the fragmented remnants of the native vegetation on the eastern side of the plain. *Ptilotus sericostachyus* subsp. *roseus* has not been collected since 1906 and is likely to be extinct.

The diminutive *Ptilotus christineae* was first recognized as a new species by the second author in 2010 during a flora and vegetation survey of the Greater Brixton Street Wetlands (GBSW) that was conducted for the V & C Semeniuk Research Group. The GBSW comprise about 120 ha of remnant native vegetation of the lower catchment of the Yule Brook in the Perth suburbs of Kenwick and Wattle Grove; they are part of a gently sloping alluvial fan formation that extends from the foothills of the Darling Range to the Canning River. The complex stratigraphy and hydrology of this area manifests as a very diverse array of fine-scale plant habitats (V & C Semeniuk Research Group 2001). The GBSW are renowned as one of the most floristically-rich areas of the SCP and they have been formally recognized as Bush Forever Site 387 (Government of Western Australia 2000). There are at least five other *Ptilotus* taxa (*P. declinatus* Nees, *P. drummondii* (Moq.) F.Muell., *P. esquamatus* (Benth.) F.Muell., *P. manglesii* (Lindl.) F.Muell. and *P. stirlingii* (Lindl.) F.Muell. subsp. *stirlingii*) that have been previously recorded in the GBSW (Keighery & Keighery 2000).

Apart from the GBSW, most of the alluvial soils of the lower catchment of the Yule Brook were cleared of native vegetation many years ago for farming. Despite the proximity of Kenwick to the city, the seasonal waterlogging or inundation of much of this area previously rendered it uneconomical for urban development. Most of the land surrounding the GBSW is still currently zoned rural but it is under review with regard to re-zoning for industrial purposes. *Ptilotus christineae,* in common with much of the biota of the GBSW, is subject to threats from the surrounding land-uses and catchment management practices.

The discovery of *P. christineae* in the GBSW highlights the remarkable floral biodiversity that continues to persist, albeit precariously and sometimes overlooked, in the Perth Metropolitan Region of the SCP.

Taxonomy

Ptilotus christineae R.W.Davis & Tauss, *sp. nov.*

Ptiloto spathulato (R.Br.) Poir. affinis sed habitu rhizomato, spica leviter interrupta, et stamina 5 (quae in *P. spathulato* 3) statim dignoscenda.

Typus: Kenwick, Western Australia [precise locality withheld for conservation reasons], 23 October 2010, *C. Tauss, K.R. Thiele & R. Davis* CT 4136 (*holo*: PERTH 08247269, *iso*: CANB).

Ptilotus sp. Brixton (C. Tauss 4136), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au/ [accessed 4 May 2011].

Perennial herb to 8 cm high. *Rhizome* glabrous, 1–1.8 mm in diam., branched. *Shoots* annual, well-spaced. *Flowering stems* erect, one per shoot, with indistinct, pink ribs, glabrous or with sparse, white, sub-verticillate hairs. *Basal leaves* glossy, spathulate, 8–35 mm long, 2–10 mm wide, glabrous or with very sparse hairs. *Cauline leaves* alternate, oblanceolate to spathulate, 8–15 mm long, 2–5 mm wide, glabrous or with very sparse hairs. *Inflorescence* spiciform, terminal, ovate, maturing to loosely cylindrical, 30–45(–50) mm long, 18–25 mm diam. *Bracts* broadly obovate, 4.2–5 mm long, translucent; midrib pink-maroon with sparse, white, sub-verticillate hairs abaxially, becoming glabrous toward margins. *Bracteoles* similar to bracts, 5–6 mm long, apices slightly recurved. *Flowers* shortly pedicellate. *Outer tepals*, lanceolate, concave, 9–9.4 mm long; adaxially white with pink margins, glabrous except for proximal, long, white, contorted, nodose hairs; abaxially pink, densely hairy, the hairs long, white and sub-verticillate. *Inner tepals*, similar to outer tepals but narrower, 8.5–8.7 mm long; margins narrowly involute; apices glabrous, translucent. *Staminal cup* symmetrical, 0.8–1 mm long, glabrous. *Stamens* 5; filaments and anthers white, ageing to pinkish. *Style* ± straight, central to sub-central, white, 1.8–2 mm long. *Ovary* stipitate, glabrous, green. *Seed* not seen. (Figure 1)

Other specimens examined. WESTERN AUSTRALIA: [precise locality withheld for conservation reasons], Kenwick, 16 Oct. 2010, *C. Tauss* 4102 (PERTH 08273065).

Phenology. In 2010, the annual shoots of *Ptilotus christineae* and *P. manglesii*, which grow in the same habitat, became evident in late June. By the time the flowers of *P. christineae* reached anthesis in early October, most of the other annual and geophytic herbs at the site were desiccated and the soil

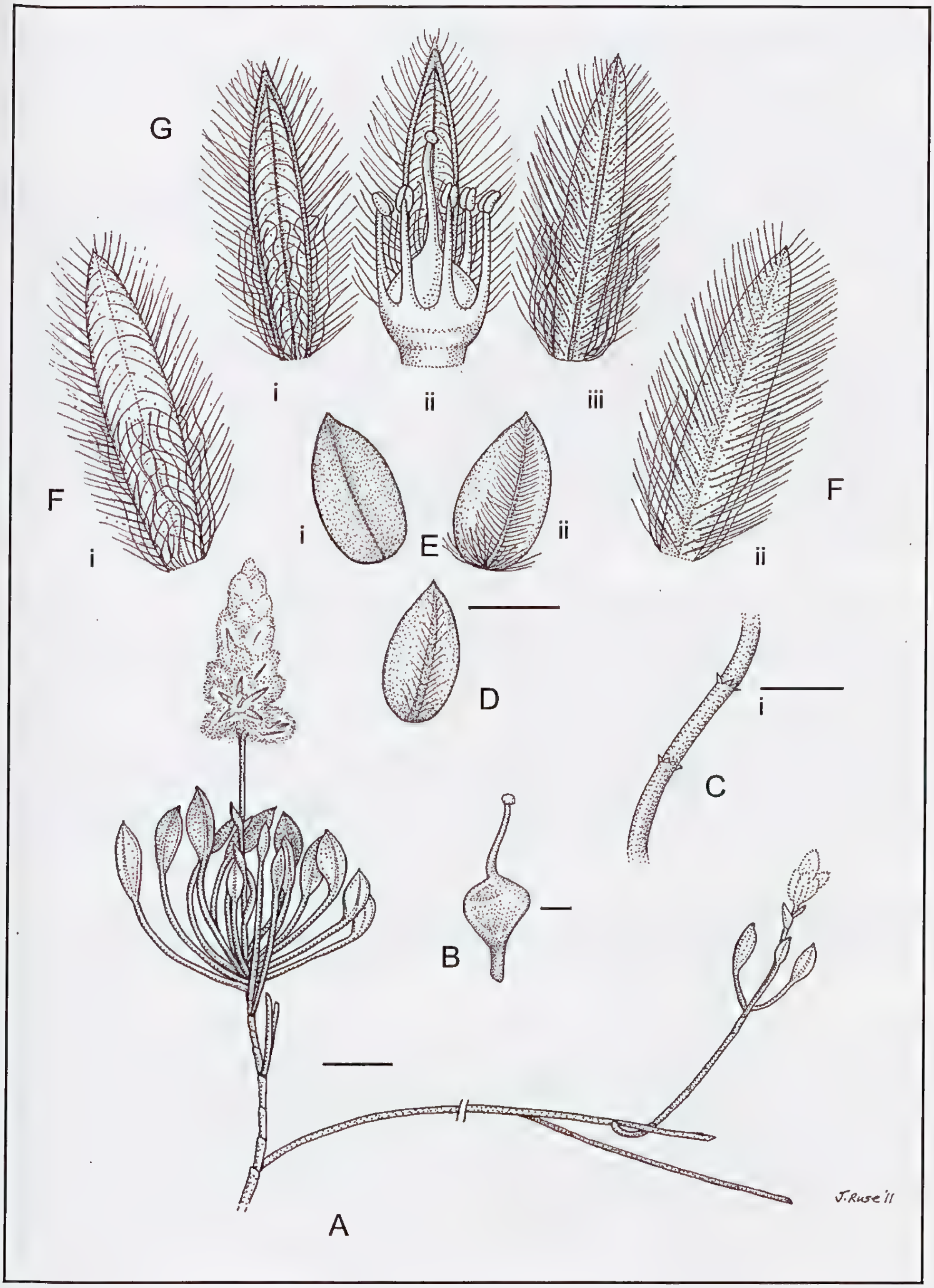

Figure 1. *Ptilotus christineae* (*C. Tauss, K.R. Thiele & R. Davis* CT4136). A – habit; B – gynoecium; C – subverticillate hairs; D – bract; E – bracteole, i) adaxial surface, ii) abaxial surface; F – outer tepals, i) adaxial surface, ii) abaxial surface; G. inner tepals, i) adaxial surface, ii) adaxial surface with stamens and ovary *in situ*, iii) abaxial surface. Scale bars: A = 20 mm; B = 1 mm; C = 0.05 mm; D–G = 2.5 mm.

surface was dry. *Ptilotus manglesii* commenced flowering at the end of October and for a short period, both *Ptilotus* were observed in full flower together.

Etymology. The specific epithet honours the contribution of Dr Christine A. Semeniuk to wetland science; her work also illuminates the study of wetland plant habitats.

Distribution and habitat. Ptilotus christineae is currently known from only one small population at the type location. The total area of occupancy of this species is estimated to be less than 0.2 ha.

Ptilotus christineae inhabits a seasonally inundated flat (floodplain) at an elevation of about 6.5 m above sea level. The site is underlain by pale grey, muddy-sand to sandy-mud alluvium (Guildford Formation) of the Pinjarra Plain (V & C Semeniuk Research Group 2001). The regional, unconfined, groundwater in most of this area of the GBSW is generally at about ground level in late winter. At a local scale, the hydrology and stratigraphy of the wetlands is complex with small, confined (artesian) aquifers and shallow aquitard layers of ferricrete or calcareous muds or clays that perch rainwater for varying lengths of time (V & C Semeniuk Research Group 2001). In 2010, despite record-breaking low rainfall in the region, the site inhabited by *P. christineae* was shallowly inundated for a short period in winter.

Ptilotus christineae was recorded in patchy *Melaleuca acutifolia* open scrub over *Verticordia plumosa* var. *brachyphylla* and *Hypocalymma angustifolium sens. lat.* open heath over *Meeboldina cana*–*Chorizandra enodis* open rushes and sedges and mid-dense, species-rich native annual herbs and geophytes. Common associates of this vegetation included *Acacia lasiocarpa* var. *lasiocarpa sens. strict.*, *Borya scirpoidea*, *Bulbine semibarbata*, *Burchardia multiflora*, *Centrolepis aristata*, *Diuris* aff. *laxiflora*, *Drosera heterophylla*, *D. menziesii* subsp. *menziesii*, *D. tubaestylis*, *Gahnia trifida*, *Hyalosperma cotula*, *Pheladenia deformis*, *Podolepis gracilis*, *Pogonolepis stricta*, *Ptilotus manglesii*, *Sowerbaea laxiflora*, *Stylidium divaricatum* and *Tribonanthes australis*. Naturalized alien taxa in this assemblage included *Heliophila pusilla*, *Romulea rosea* var. *communis* and *Sparaxis bulbifera*.

Threats. Ptilotus christineae is threatened by off-road vehicles, hydrological and climatic change, nutrient enrichment of groundwater, invasive naturalized alien plants (particularly *Sparaxis bulbifera*, *Morea flaccida* and *Hyparrhenia hirta*, which are prevalent in the area), rabbits and frequent fires.

The current municipal drainage scheme does not consider the environmental water requirements of the vegetation in the GBSW. Subsequent to the extensive vegetation clearing in the Yule Brook catchment and the resulting increase in the volume of runoff, the brook was excavated to mitigate the flooding of adjacent properties and to convey rainwater (part of which previously infiltrated into the groundwater in the GBSW) directly into the Canning River. The GBSW are thus no longer subject to natural, regular flooding and alluvial sediment supply from the Yule Brook. A number of other excavated drains, firebreaks and vehicle tracks in the area intersect some of the local, shallow aquifers and also contribute to the dewatering of the GBSW (V & C Semeniuk Research Group 2001). The adverse impact of these changes on the hydrological regime of the GBSW will be exacerbated by the trend towards a drier climate that is now evident in the SCP.

There is continuing uncertainty of the land tenure of many blocks in the GBSW and currently no overall plan to manage the wetlands, to ameliorate the impacts of the surrounding land uses on the native vegetation and to guide local planning authorities.

Conservation status. *Ptilotus christineae* is currently listed as a Priority One species under the Department of Environment and Conservation's Conservation Codes for Western Australian Flora (Smith 2010), as *Ptilotus* sp. Brixton (C. Tauss 4163). It is only known from one small population with a very small area of occupancy that is vulnerable to clearly demonstrable threats.

The Greater Brixton Street Wetlands and about 400 ha of the adjoining rural lands have been searched by the second author in several intensive, multi-season surveys (including Tauss & Weston 2010) and no other occurrences of *Ptilotus christineae* have been found. It is unlikely that other populations will be located in the SCP as the habitat of this species is scarce and has been thoroughly explored (Government of Western Australia 2000) due to its high conservation values.

Affinities. In a vegetative state, *Ptilotus christineae* bears a superficial resemblance to *Ptilotus spathulatus* (R.Br.) Poir. as both have fleshy, spathulate, basal leaves. However, there are clear floral, habit and distribution differences between the two species. *Ptilotus spathulatus* has three stamens and two staminodes, a broadly curved or sigmoid style that is eccentrically attached to the ovary and hairs that are mainly verticillate. In addition, *P. spathulatus* has a hard, woody, rootstock that produces several to many prostrate flowering stems on each plant, and a denser inflorescence than *P. christineae*. *Ptilotus spathulatus* is only known from well-drained sites in the semi-arid zone of the South West Botanical Province of Western Australia.

Ptilotus christineae is clearly distinguished from all congeners in the SCP by the combination of its slender rhizome, spathulate leaves, erect flowering shoot, five fertile stamens and wetland habitat.

Key to *Ptilotus* taxa of the Swan Coastal Plain Biogeographical Region

1. Plants with 5 fertile stamens
  2. Branches (or scape, in *P. christineae*) erect or arching
    3. Interstaminal lobes absent, leaves spathulate .... **P. christineae**
    3: Interstaminal lobes present, leaves narrow and linear .... **P. drummondii**
  2: Branches prostrate
    4. Inflorescences ovoid to globose, tepal indumentum sericeous .... **P. esquamatus**
    4: Inflorescences cylindrical, tepal indumentum woolly .... **P. humilis**
1: Plants with 2–4 fertile stamens
  5. Fertile stamens 2
    6. Staminal cup glabrous, style slightly curved .... **P. stirlingii** subsp. **stirlingii**
    6: Staminal cup hairy, style markedly falcate
      7. Bracteoles 5–6.5 mm long .... **P. sericostachyus** subsp. **sericostachyus**
      7: Bracteoles 7.5–8 mm long .... **P. sericostachyus** subsp. **roseus**
  5: Fertile stamens 3–4
    8. Outer tepals with sparse, short, stiff hairs
      9. Tepals 11–14 mm long, style 8–10 mm long .... **P. gaudichaudii** subsp. **gaudichaudii**
      9: Tepals 6–9 mm long, style 2–3 mm long .... **P. gaudichaudii** subsp. **eremita**

8: Outer tepals with dense, long, soft hairs

10. Branches erect, inflorescences predominately white-green

11. Inflorescences ovoid, hemispherical or orbicular, style 2.5–4.6 mm long.................... **P. divaricatus**

11: Inflorescences cylindrical, style 7–13 mm long.. **P. polystachyus**

10: Branches prostrate, inflorescences predominantly pink-purple

12. Basal leaves present, bracts brown, style more or less straight....................................... **P. manglesii**

12: Basal leaves absent, bracts translucent, style markedly falcate .... **P. declinatus**

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References

Department of Environment, Water, Heritage and the Arts (2008). *Interim Biogeographic Regionalisation of Australia (IBRA) Version 6.1.* http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html [accessed June 28 2011].

Government of Western Australia (2000). *Bush forever: keeping the bush in the city.* (Dept. of Environmental Protection: Perth.)

Keighery, G.J. & Keighery, B.J. (2000). The flora of the Greater Brixton Street Wetlands. *In*: Marshall, J. (ed.). *The Brixton Street Wetlands: management guidelines, natural history and research.* p. 15–34. Unpublished report for the Friends of Brixton Street Wetlands Inc. Kenwick, Western Australia.

Smith, M.G. (2010). *Declared Rare and Priority Flora List for Western Australia.* (Department of Environment and Conservation: Kensington, WA.)

Tauss, C. & Weston, A.W. (2010). *The flora, vegetation and wetlands of the Maddington-Kenwick Strategic Employment Area. A survey of rural lands in the vicinity of the Greater Brixton Street Wetlands.* Unpublished report to the City of Gosnells, Western Australia.

Townsend, C.C. (1993). Amaranthaceae. *In*: Kubitzki, K. (ed.). *The families and genera of vascular plants.* Vol. 2, 86–87. (Springer-Verlag: Berlin.)

V & C Semeniuk Research Group (2001). *Hydrological study of the Greater Brixton Street Wetlands.* Unpublished report to the Friends of Brixton St Inc. Kenwick, Western Australia.

Western Australian Herbarium (1998–). *FloraBase–the Western Australian Flora.* Department of Environment and Conservation. http://florabase.dec.wa.gov.au/ [accessed June 28 2011].

An assessment of some infraspecific taxa in *Ptilotus* (Amaranthaceae) from Western Australia

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Abstract

An assessment of some infraspecific taxa in *Ptilotus* (Amaranthaceae) from Western Australia. *Nuystia* 21(3): 103–106 (2011). This paper deals with three infraspecific taxa in *Ptilotus* R.Br. that do not warrant recognition: *Ptilotus appendiculatus* Benl var. *minor* Benl, *Ptilotus divaricatus* (Gaudich.) F.Muell. var. *rubescens* Benl and *Ptilotus lanatus* Cunn. ex Moq. var. *glabrobracteatus* Benl.

Introduction

This paper is a continuation of work begun by Davis (2009) to assess the validity of infraspecific taxa within the genus *Ptilotus* R.Br. in preparation for a *Flora of Australia* treatment of the Amaranthaceae.

Gerhard Benl (1910-2001) was one of the most prolific authors on the genus *Ptilotus* (Benl 1959, 1980, 1983, 1994). However, in the 17 years since Benl (1994) described his last new taxon in *Ptilotus*, there has been a substantial growth in collections, allowing a reappraisal of some of his taxa. Benl's taxonomy was detailed and he attempted to provide a taxonomic rank for many minor variants, even ones represent by only one or very few specimens. Bean (2008) noted that some of Benl's infraspecific taxa have proven of little or no taxonomic value after modern reappraisals.

The purpose of this paper is to reduce to synonymy infraspecific taxa that are now regarded as having no taxonomic merit.

Ptilotus appendiculatus Benl, *Muelleria* 1: 102 (1959). *Type*: Western Australia – Globe Hill Station, Ashburton River, 6 Oct. 1905 , *A. Morrison* 15098 (*holo*: K, image seen; *iso*: E).

Ptilotus appendiculatus var. *minor* Benl, *Nuytsia* 4: 267 (1983). *Type*: Boodardee, about 15 miles (24 km) W of Port Hedland, Western Australia, 9 Sept. 1969, *S.L. Everist* 9195 (*holo*: BRI!).

Benl erected var. *minor* on the basis of a single specimen, which diverged from var. *appendiculatus* in its 'much-branched habit, smaller spikes with narrower flowers and less conspicuous appendages of the outer tepals' (Benl 1983: 267). At the time the distance between the single collection of var. *minor* and the nearest var. *appendiculatus* was *c.* 350 kilometres. Benl noted that there appeared to be habitat differences between the two taxa, with var. *minor* occurring on a flood plain and var. *appendiculatus* apparently restricted to 'spinifex [*Triodia*] hills' (Benl 1983: 269). Benl described the ovary as 'almost glabrous' in var. *minor* and 'sparsely pilose at the summit' in var. *appendiculatus*. He also suggested that the two taxa differed in flower colour, noting that Everist (*in sched*., *S.L. Everist* 9195) had described the flowers of var. *minor* as 'white to pale ivory coloured' and that in collections of var. *appendiculatus* (e.g. *W.H. Butler s.n.*, 9 Aug. 1963) the tepals were 'tinged pink' (Benl 1983: 269). Despite these apparent differences, Benl noted that some collections of the typical form (e.g. *W.H. Butler s.n.*; *R. Pratt* 2/0199) had a 'branching pattern resembling that of var. *minor*' (Benl 1983: 269); on this basis he described the latter (var. *minor*) at varietal rank.

On examining the wider range of specimens now available at PERTH, branching habit varies continuously from little- to much-branched in *P. appendiculatus*. The type collection of var. *minor* is of a juvenile plant, and the tepals are fractionally smaller than in most specimens (10–10.9 mm long *cf* 11–13.4 mm long). Flower size in *Ptilotus* can be affected by both age of plants and seasonal factors: in drier seasons plants often produce smaller flowers. The outer tepal appendages, although slightly smaller in var. *minor*, are consistent in shape between both taxa.

When var. *minor* was described there was a significant geographical disjunction (*c*. 350 km) between its type locality and the nearest specimens of the typical variety. Since then, further collecting has partially filled the gap, which is now reduced to *c*. 200 kilometres. *Ptilotus appendiculatus* is now known to occur in a variety of habitats throughout the south-west region of the Pilbara including flood plains, colluvial flats and stony hills.

The type of var. *minor* has a glabrous ovary; in specimens of var. *appendiculatus* the ovary ranged from densely pilose to sparsely pilose along the ovary summit, to glabrous. Ovary indumentum is not an adequate discriminating character in *Ptilotus appendiculatus*.

Benl's comments regarding flower colour are problematic for two reasons; firstly, Everist may have been referring to spike colour in his description of var. *minor* while Butler was referring to individual tepals in var. *appendiculatus*. Flowering spikes in *P. appendiculatus* have a lighter overall appearance because of the dense tepal indumentum. The second problem is that individual collector's interpretations of flower colour are likely to vary.

Selected specimens examined. WESTERN AUSTRALIA: 11 km S of Mount Delphine, West Hamersley Range, 27 July 1999, *B. Backhouse, D. Edinger & G. Marsh* BEM 151 (PERTH); 6 miles N of Cane River, 9 Aug. 1963, *W.H. Butler s.n.* (PERTH); Barrow Island, 6 Aug. 1973 *W.H. Butler* 178 (PERTH); *c*. 20 km E of Pannawonica, Pilbara, M5-8, Jul. 1999, *P. Ellery s.n.* (PERTH); Bullara turnoff, *c*. 1 mile E of Yanrey Homestead, 29 Aug. 1960, *A.S. George* 1169 (PERTH); near Quarry Hill, *c*. 125 km W of Tom Price, 8 Aug. 1984, *K.R. Newbey* 10799 (CANB, K, PERTH); 60 miles S of Onslow, 11 Sep. 1961, *F. Smith s.n.* (PERTH); 14.5 km SSW of Panawonnica and 300 m W of Jimmawurrada Creek, 13 Aug. 1991, *M.E. Trudgen & S. Maley* MET 10279 (CANB, PERTH,); North West Coastal Highway, 26 km west of Barradale, 30 Aug. 2003, *J.E. Wajon* 883 (PERTH).

Ptilotus divaricatus (Gaudich.) F.Muell., *Fragm*. 6: 229 (1868). *Trichinium divaricatum* Gaudich. in L. de Freycinet, *Voy. Uranie Bot*. 445 (1829). *Type*: Shark Bay, Western Australia, 1817–1820, *C. Gaudichaud* 71 (*holo*: P, *n.v.*; *iso*: BM, *n.v.*, G, *n.v.*).

Trichinium striatum Moq. ex Benth., *Fl. Austral.* 5: 233 (1870); *Ptilotus striatus* (Moq. ex Benth.) F.Muell., *Syst. Census Austral. Pl.* 1: 28 (1882). *Type*: Swan River, Western Australia, 1843, *J. Drummond* 430; Port Gregory [Western Australia], *A.F. Oldfield s.n.*, (*n.v.*); Dirk Hartog Is. [Western Australia], *W.G. Milne s.n.*, (*n.v.*)

Ptilotus divaricatus (Gaudich.) F.Muell. var. *rubescens* Benl, *Nuytsia* 3: 169 (1980). *Type*: *c.* 1 km NE of Bore Camp, Dirk Hartog Island, Western Australia, 6 Sep. 1972, *A.S. George* 11578 (*holo*: PERTH 1555057!; *iso*: CANB).

Benl described *Ptilotus divaricatus* var. *rubescens* on the basis that it diverged from typical *P. divaricatus* in having 'red flowers' and 'the initial development of the inflorescence from cone-shaped, turning ovoid or sub-spherical' (Benl 1980: 169). In the label notes accompanying the specimen, the collector noted that the flowers were pink and that white-flowering plants (i.e. typical *P. divaricatus*) were not known on Dirk Hartog Island. Further collections lodged in PERTH indicate that in some populations (e.g. *A. Carr* 591) white- and pink-flowering plants grow in mixed stands, with all hues in between. Flower and inflorescence colour is a variable feature in many taxa of *Ptilotus*, both within and between populations. Assessment of a wide range of specimens shows that the development of flowering spikes in *P. divaricatus* is the same between white- and pink-flowering forms.

Selected specimens examined. WESTERN AUSTRALIA: between Tamala & Carrarang, 11 Oct. 1973, *J.S. Beard* 6808 (PERTH); Dongara, Irwin River Estuary Nature Walk Trail, Church Street, 17 Oct. 2000, *A. Carr* 566 (PERTH); near the monastery (Benedictine retreat) E side, road to monastery is N side Ocean Drive *c.* 2 km from town centre, 23 Nov. 2001, *A. Carr* 591 (PERTH); Urchin Point, Dirk Hartog Island, 8 Oct. 1997, *D.J. Edinger* 1250 (PERTH); Cape Range National Park, 8 Aug. 2006, *J. English* 0107 (PERTH); *c.* 48 km East of Mount Narryer, 14 Oct. 1998, *A.S. George* 17504 (PERTH); East Wallabi Island, Abrolhos Islands, 18 Nov. 1999, *J. Harvey s.n.* (PERTH); Peron Peninsula, 30 Apr. 1996, *G. Liddelow* SB 13 (PERTH); Shark Bay, 5 Oct. 1989, *M.E. Trudgen* 7448 (PERTH).

Ptilotus lanatus Cunn. ex Moq. in A.P. de Candolle, *Prodr.* 13(2): 281 (1849). *Trichinium lanatum* (Cunn. ex. Moq.) Druce, *Bot. Soc. Exch. Club Brit. Isles* 1916, 2nd Suppl. 651 (1917), *nom. illeg.*, *non* Lindl. (1838). *Type*: Swan Bay, N.W. Australia, 1835, *A. Cunningham s.n.* (*holo*: K, *n.v.*).

Trichinium cunninghamii Benth., *Fl. Austral.* 5: 238 (1870). *Ptilotus cunninghamii* (Benth.) F.Muell., *Pl. NW Australia* 7 (1887), *nom. illeg. Type*: Point Cunningham, Cygnet Bay, King Sound [Western Australia], 1822, *A. Cunningham* 153 (*holo*: BM, *n.v.*; *iso*: K, *n.v.*, MEL, *n.v.*).

Ptilotus lanatus Cunn. ex Moq. var. *glabrobracteatus* Benl, *Muelleria* 1: 107 (1959) *Type*: near King Sound, Western Australia, 1887, *W.W. Froggat* 15 (*holo*: MEL; *iso*: K, image seen, MEL, NSW).

In describing *Ptilotus lanatus* var. *glabrobracteatus*, Benl (1959) cited differences in the lengths of the bracts and bracteoles between var. *lanatus* (bracts to 2.3 mm long and bracteoles to 1.8 mm long) and var. *glabrobracteatus* (bracts to 3.5 mm long and bracteoles to 2mm long), as well as density of the indumentum on these floral parts. He noted at the time of publication that there were intermediates. On examining current PERTH collections there is an imperceptible gradation of indumentum density. In the specimens examined var. *lanatus* bracts ranged from 1.4–2.5 mm long and bracteoles 1.2–1.8 mm long; and in var. *glabrobracteatus* bracts ranged from 2–2.8 mm long and bracteoles 1.3–2 mm long. This shows a clear overlap of bract and bracteole lengths between the two taxa.

Selected specimens examined. WESTERN AUSTRALIA: Derby to Broome road, 20.3 km S (by road) of Derby, 19 Apr. 1985, *T.E.H. Aplin et al.* 76 (CANB, PERTH); 67 km NE of Lagrange Aboriginal Mission turnoff, Great Northern Highway, 1 Sep. 1978, *A.C. Beauglehole & E.G. Errey* B 59158 E 2858 (ACB, CANB, PERTH); One Arm Point, N Dampier Peninsula, Kimberley Coast, 28 Feb. 1989, *B.J. Carter* 356 (DNA, PERTH); 2 km on Beagle Bay Road from Broome, 12 May 1985, *P.R. Foulkes* 234 (PERTH); Broome, 2 May 1944, *C.A. Gardner* 7030 (CANB, PERTH); 5 km N of Point Coulomb, Dampierland, N of Broome, 17 Apr. 1977, *K.F. Kenneally* 5923 (CANB, K, MUN, PERTH); Camballin, May 1970, *Y. Power* 784 (L, PERTH); 66 miles E of Derby on road to Fitzroy Crossing, 10 Mar. 1967, *F. Power* 172 (PERTH) Mount Anderson Station, E of Derby, 3 Apr. 1964, *R.D. Royce* 8143 (CANB, PERTH); Lanlacatta Swamp on Camballin Station, Kimberley, 27 July 1997, *L. Wallis* LW 97A/120 19 Apr. 1985 (CANB, PERTH).

References

Bean, A.R. (2008). A synopsis of *Ptilotus* (Amaranthaceae) in eastern Australia. *Telopea* 12(2): 227–250.

Benl, G. (1959). New species and varieties of *Ptilotus* R.Br. (Amaranthaceae). *Muelleria* 1: 107.

Benl, G. (1980). Five new taxa of *Ptilotus* (Amaranthaceae) from Western Australia. *Nuytsia* 3: 169.

Benl, G. (1983). Taxonomic studies of *Ptilotus* R.Br. (Amaranthaceae) in Western Australia. *Nuytsia* 4: 269–270.

Benl, G. (1994). *Ptilotus mitchellii* (Amaranthaceae), a new species from the Pilbara region, Western Australia. *Sendtnera* 2: 25–30.

Davis, R.W. (2009). *Ptilotus luteolus*, a new combination in *Ptilotus* (Amaranthaceae). *Nuytsia* 19: 311–312.

A revision of *Dielsiodoxa* (Ericaceae: Styphelioideae: Oligarrheneae)

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Abstract

Albrecht, D. E. & Hislop, M. A revision of *Dielsiodoxa* (Ericaceae: Styphelioideae: Oligarrheneae). *Nuytsia* 21(3): 107–126 (2011). The genus *Dielsiodoxa* Albr., endemic to south-west Western Australia, is revised. The genus includes three previously named species, *D. leucantha* (E.Pritz.) Albr., *D. oligarrhenoides* (F.Muell.) Albr. and *D. tamariscina* (F.Muell.) Albr. A neotype is designated for the former species and a lectotype for the latter species. Three new taxa are described with accompanying scanned images: *D. lycopodioides* Albr., *D. propullulans* Albr. and *D. leucantha* subsp. *obtusa* Hislop & Albr. Descriptions, a distribution map and a key to all taxa are provided.

Introduction

In a recent paper Albrecht *et al.* (2010) erected a new genus *Dielsiodoxa* Albr. to accommodate three Western Australian species previously included within *Monotoca* R.Br. Based on morphological and molecular data they place *Dielsiodoxa* in the Oligarrheneae Crayn & Quinn as a sister to *Oligarrhena* R.Br. *Dielsiodoxa* is distinguished from *Oligarrhena* in having a 5-lobed corolla that is not laterally compressed (*cf.* consistently 4-lobed and laterally compressed in *Oligarrhena*), the lobes widely spreading at anthesis and lacking adaxial sub-marginal flaps (*cf.* lobes erect and with sub-marginal flaps in *Oligarrhena*), 5 stamens with the anthers attached near the midpoint to filaments that distinctly taper upwards (*cf.* 2 stamens with basifixed anthers and filaments not obviously tapering distally in *Oligarrhena*).

The three currently named species of *Dielsiodoxa* (*D. tamariscina*, *D. oligarrhenoides* and *D. leucantha*) were described prior to 1905 as species of *Monotoca*. The taxonomy of this group of species has not been reassessed in the past century and the only treatment that includes all three species (as *Monotoca*) is in *How to know Western Australian wildflowers* (Blackall & Grieve 1981). At least one name was misapplied in that treatment and in some instances the species concepts are too broad. We have endeavoured to address these issues in the revision of *Dielsiodoxa* presented here, which is based on morphological data.

Methods

Morphological observations are based on collections held at CANB, MEL, NSW, PERTH and UNSW. Measurements were made with a binocular light microscope fitted with an eyepiece graticule. Dried material was rehydrated by boiling prior to measuring. Leaf measurements were made on fully expanded flattened leaves. Leaf density was assessed on well developed vegetative shoot growth below the actively expanding distal section. The width of the raised leaf abscission scars on branchlets was measured on dried material. Leaf vein number was assessed along an imaginary transverse line at the midpoint of the leaf. Leaf venation pattern was examined on representative specimens after soaking in bleach for several days. Peduncle length was measured as the distance between the base of the peduncle and the lowermost bract (sterile or subtending a flower or fruit). Fruit length measurements excluded the persistent style. Stigma cleft depth was measured as the vertical distance between the base of the cleft and an imaginary transverse line between the tips of the two stigmatic lobes.

Leaves and, to a lesser extent, flowers readily dissociate from specimens when they dry, and herbarium specimens frequently have fragments loose in the specimen folders or in packets attached to the specimen. Caution was exercised when examining such fragments as it was not uncommon to find fragments of other *Dielsiodoxa* species mixed with the species mounted on the sheet.

Details of growth form, plant height, flower colour, habitat and locality were taken from the collector's notes recorded on the herbarium specimen label. Geocode data from PERTH specimens were plotted using DIVA-GIS Version 5.2.0.2 to produce the distribution maps.

Morphology

Growth patterns. The way in which new growth is initiated on branchlets appears to vary between species and certainly has value in distinguishing *D. propullulans* and *D. leucantha*. The axis of fertile branchlets usually continues vegetative growth beyond the uppermost fertile nodes in most taxa, as exemplified in *D. propullulans*. Additionally, some taxa may initiate new growth from within or rarely below the fertile section. *Dielsiodoxa leucantha* on the other hand appears to initiate new growth almost exclusively from below the fertile section of the branchlet or occasionally produces very short, abortive growth beyond the uppermost fertile nodes. Further field study is required to confirm observations made from herbarium material.

Leaves. All species have dense, sessile leaves with lunate, non-sheathing bases. Most species have helical leaf arrangement with the exception of *D. oligarrhenoides*, which is decussate. *D. oligarrhenoides* also differs from other species in having thick-textured leaves with the venation not visible on the abaxial side. The number of veins has some utility in distinguishing *D. lycopodioides*, as does the width of scars left on the branchlets when the leaves abscise. Leaf shape, width and length/width ratio are useful diagnostic characters for some taxa when used in combination with other characters.

Differences in leaf shape and dimensions were noted between seedling and adult plants of *D. propullulans*. For example the seedlings represented on *J.M. Powell* 2231A have long, lanceolate leaves (e.g. approximately 4.2 mm long x 0.9 mm wide), whereas adult specimens of this species have considerably shorter and broader leaves. The sample of specimens taken from immature plants is presently too small to assess the occurrence of leaf dimorphism in the genus more generally.

Flowers. Members of the genus have tiny bisexual flowers with a persistent 5-lobed corolla, upwardly tapering filaments, exserted anthers that are distinctly concave abaxially, free nectary scales and a 2-locular ovary and 2-lobed stigma. Relatively few floral characters have taxonomic value. Bracteole and sepal apex shape varies within the genus and can be useful for distinguishing some taxa when used with other characters. The presence of hairs on the external surface of the corolla is distinctive for *D. tamariscina*, all other taxa having glabrous corollas. Further field work is required to determine whether there are any consistent differences in fresh corolla colour between taxa. All taxa have ovaries (and fruit) with a smooth or weakly textured surface except for *D. lycopodioides*, which has a distinctly pustulate surface, albeit minutely so.

Fruit. All species of *Dielsiodoxa* have a dry, indehiscent fruit. Following Albrecht *et al.* (2010), we have used the general term 'nut' to describe this fruit type, though the more specific term achene (*sensu* Stuppy 2004) also appears to be applicable.

Susceptibility to disease

It is probable that all species of *Dielsiodoxa* are susceptible to *Phytophthora cinnamomi*. This is particularly problematic for the taxa that have a very restricted geographical range. Formal declaration as threatened flora may be appropriate for some taxa, and specific conservation measures may need to be implemented to ensure the long-term persistence of some populations. Species-specific information where available, is given under the species treatments.

Research needs

Albrecht *et al.* (2010) included limited *Dielsiodoxa* sequence data from two chloroplast encoded regions in their analyses. The *mat*K gene and the *atp*B-*rbc*L intergenic spacer were successfully sequenced for *D. leucantha* subsp. *obtusa* and *D. propullulans*, and the *mat*K gene for *D. leucantha* subsp. *leucantha*. Around the time that the Albrecht *et al.* paper was submitted for publication, material of *D. lycopodioides* and *D. tamariscina* was sent to Chris Quinn at NSW for extraction and sequencing, however sequences for these two species were not successfully obtained. Further attempts to gain sequence data for these two species would be worthwhile. In addition, a more comprehensive infraspecific sampling, utilising several DNA markers, would be particularly valuable in the case of *D. leucantha*, by far the most variable species recognised here and one with a remarkably disjunct distribution pattern.

To the best of our knowledge chromosome counts have never been obtained for any species of *Dielsiodoxa*. Chromosome numbers may provide valuable additional data for assessing relationships.

Limited fire response data is available for *Dielsiodoxa* species. *Dielsiodoxa lycopodioides* [as *Monotoca tamariscina*] is recorded as a strict seeder by Bell (1995). Other genera in the Oligarrheneae, namely the monotypic *Oligarrhena* and *Needhamiella* L. Watson are also strict seeders (Bell 1995; Bell *et al.* 1996). It is likely that all species of *Dielsiodoxa* are strict seeders, however this needs confirmation by field observations or anatomical sectioning.

Taxonomy

Dielsiodoxa Albr., *Austral. Syst. Bot.* 23: 329–330 (2010). *Type*: *Dielsiodoxa tamariscina* (F.Muell.) Albr.

Shrubs, mostly small; branchlets with an indumentum of short simple hairs, dense raised leaf abscission scars evident on older branchlets; winter-bud scales similar to leaves, non-deciduous. *Leaves* dense, short, helical or decussate, erect to appressed, readily abscising from dried specimens when touched; primary veins subparallel-palmate, unbranched or outermost branched only in the proximal half, often weakly visible on abaxial side; fibre bundles not touching adaxial or abaxial epidermis; abaxial surface lacking both papillae and ribbon wax; the outer wall of epidermal cells unlignified and unthickened, collapsing inwards on drying; minute hairs or teeth present somewhere on margins; apex straight to incurved, mucronulate or not; base non-sheathing, lunate in transverse section, lacking a petiole. *Inflorescences* axillary, few-flowered spikes lacking a rudiment, sometimes reduced to a single flower; spikes with a persistent bract subtending each flower, with or without sterile proximal bracts. *Flowers* bisexual, each subtended by a pair of persistent bracteoles; bracteoles glabrous except for minutely ciliolate margins, inserted immediately below the sepals. *Sepals* 5, persistent, glabrous except for minutely ciliolate margins; stomata absent on adaxial surface, absent or rare near the margins on abaxial surface. *Corolla* radially symmetrical, white to pale yellowish-green, persistent in fruit and turning brown in dried material, glabrous or rarely with sparse short hairs externally; tube shallowly U-shaped, equal to or shorter than corolla lobes, equal to or slightly exceeding the sepals; lobes typically 5 (rarely 4, 6 or 7-lobed), valvate in bud, midvein apparent, widely spreading at anthesis, lacking adaxial sub-marginal flaps. *Stamens* equal to corolla-lobe number; anthers tiny, bisporangiate, lacking appendages, strongly exserted from the corolla tube at maturity, attached to filament near the midpoint in a depression between the two microsporangia; filaments inserted in the throat of the corolla tube, distinctly longer than anthers, fine and distinctly tapering upwards. *Pollen* all shed as prolate pseudomonads; exine infolds with verrucate ornamentation. *Nectary scales* free, chartaceous. *Ovary* exceeding corolla tube, glabrous, smooth or textured with weakly to distinctly raised surface cells, 2(3)-locular with apical placentation, with a single ovule in each cell, ovoid to ellipsoid, ellipsoid in transverse section, tapering to a very short style; stigma 2(3)-lobed. *Fruit* a nut, apparently only one seed developing.

A genus of five species, all endemic to the south west botanical province of Western Australia.

Key to species of *Dielsiodoxa*

Notes on using key to species. Due to leaf curvature and the small size of fertile organs it is advisable to assess fresh or rehydrated material, preferably with a microscope fitted with an eyepiece graticule. Leaf width dimensions (including those used in l/w ratios) in the key are based on flattened mature (not seedling) leaves. Fruit length excludes the persistent style. Stigma cleft depth is the vertical distance between the base of the cleft and an imaginary line between the tips of the two stigmatic lobes.

1. Leaves usually decussate, occasionally helically arranged on some branchlets, thick-textured, venation not evident on abaxial side; apex of sepals obtuse .... **1. D. oligarrhenoides**

1: Leaves always helically arranged, thin-textured, venation at least weakly evident on abaxial side of some leaves; apex of sepals acute to obtuse 2

2. Outer surface of corolla tube and lower part of corolla lobes with sparse short hairs; restricted to the Stirling Ranges .... **2. D. tamariscina**

2: Outer surface of corolla glabrous 3

3. Ovary and fruit appearing densely and minutely pustulate due to distinctly raised surface cells; fruit 0.8–1 mm long; mature leaves subulate, lanceolate, ovate or rarely narrowly rhombic, 0.8–5.2 mm long, 0.3–1.1 mm wide, with l:w ratio of 2–13:1; 1–7 veins weakly visible on the abaxial leaf surface; raised leaf abscission scars 0.10–0.35 mm wide .... **3. D. lycopodioides**

3: Ovary and fruit smooth or with minute, dense, slightly raised, elongated surface cells; fruit 1.0–1.4 mm long; mature leaves ovate, depressed ovate to broadly rhombic-elliptic, 1.3–3.0 mm long, 0.9-2.5 mm wide, with l:w ratio of 0.7–2.1:1; 7–13 veins visible on the abaxial surface; raised leaf abscission scars (0.3–)0.4–0.7 mm wide 4

4. Axis of fertile branchlets usually continuing growth beyond the uppermost fertile nodes at anthesis, new growth sometimes also shooting from within fertile section of branchlet; leaves subtending inflorescences (from central part of fertile section of branchlet) broadly ovate, depressed ovate or rarely broadly rhombic-elliptic 1.5–2.2 mm wide, apex acute though sometimes appearing obtuse due to the abruptly incurved hidden tip that is at right angles to the axis of the leaf; shrub with comparatively few, mostly erect and straight branchlets; restricted to the Mt Ragged area .... **D. propullulans**

4: Axis of fertile branchlets usually not continuing growth beyond the uppermost fertile nodes at anthesis, if occasionally vegetative shoot beginning to grow through, then these very short and abortive, new growth more often shooting from below fertile section of branchlet; leaves subtending inflorescences (from central part of fertile section of branchlet) broadly rhombic-elliptic to broadly rhombic-ovate 0.6–1.5 mm wide, apex acute to acuminate, almost straight to distinctly incurved, the tip usually at an angle of 45 degrees or less relative to the leaf axis, very occasionally at right angles; west of Ravensthorpe 5

5. Bracteoles usually acute or subacute, rarely obtuse, ovate to broadly ovate (usually longer than wide) 0.4–0.7 (–0.8) mm long; sepals usually acute or subacute, occasionally obtuse 0.7–1.1 mm long; corolla tube (0.65–) 0.75–1.00 mm long; nectary scales variously shaped from oblong, lanceolate, oblanceolate to narrowly elliptic, (0.30–) 0.45–0.70 mm long; stigma cleft 0.05–0.18 mm deep .... **5a. D. leucantha** subsp. **leucantha**

5: Bracteoles usually obtuse, rarely subacute, broadly ovate to depressed-ovate (usually shorter than wide), 0.30–0.50 (–0.55) mm long; sepals usually obtuse, occasionally subacute, 0.50–0.75 (–0.85) mm long; corolla tube 0.5–0.8 mm long; nectary scales obovate to oblong-obovate, 0.25–0.40 (–0.55) mm long; stigma cleft 0.02–0.10 mm deep .... **5b. D. leucantha** subsp. **obtusa**

Descriptions

1. **Dielsiodoxa oligarrhenoides** (F.Muell.) Albr., *Austral. Syst. Bot.* 23: 330 (2010).

Monotoca oligarrhenoides F.Muell., *Fragm.* 9: 47 (1875). *Styphelia oligarrhenoides* (F.Muell.) F.Muell., *Syst. Census Austral. Pl.* 107 (1882). *Type*: Prope promontorium Cape Arid [Western Australia, *s. dat.*], *G. Maxwell s.n.* (*holo*: MEL 607256!).

Monotoca oligarrhenoides subsp. Gibson (R.D. Royce 3573) in G.Paczkowska & A.R.Chapman, *West. Austral. Fl: Descr. Cat.* 242 (2000), *p.p.*

Erect, spreading or sprawling densely branched, often compact *shrub* c. 0.15–0.50 (–1) m high. *Main stems and branches* grey to grey-brown, with longitudinally cracking persistent bark; *lateral branchlets* moderately fine, straight to somewhat curved, often entwined, grey-brown to brown, with an indumentum of variously orientated overlapping hairs 0.05–0.10 mm long, leaf abscission scars 0.3–0.8 mm wide. *Leaves* erect or ascending, decussate or occasionally helically arranged on some branchlets, densely imbricate with *c.* 20–48 leaves per cm, somewhat persistent in dried specimens but readily abscising when touched, rhombic to ovate, 0.7–2.0 mm long, 0.6–1.1 mm wide, thick-textured, rigid, strongly concave adaxially in proximal half and shallowly concave to more or less plane above, slightly keeled abaxially, adaxial and abaxial surfaces glabrous, concolorous, venation not visible; margins extremely narrow hyaline for the greater part, minutely ciliolate-serrulate, sometimes with longer hairs to 0.1 mm long on lower margins; apex not to slightly incurved, obtuse to subacute, lacking a mucro. *Inflorescences* (1)2 or 3(4)-flowered, borne on branchlets in a fertile section of variable length, the axis of fertile branchlets usually continuing growth beyond the uppermost fertile nodes at anthesis, new growth sometimes also shooting from within and rarely from below; *spike axis* 0.5–1.0 mm long including peduncle 0.3–0.6 mm long; *bracts* broadly rhomboid-ovate, often boat-shaped, 0.2–0.5 mm long, sterile proximal bracts absent or rarely 1 present; *bracteoles* broadly rhomboid-ovate, 0.3–0.5 mm long, 0.3–0.4 mm wide. *Sepals* ovate, 0.5–0.7 mm long, 0.3–0.5 mm wide, apex obtuse. *Corolla* (4)5(6)-lobed, mostly described as pale yellow in vivo at anthesis but label data also includes cream, greenish-white, yellow-green and green, presenting as rich brown post-anthesis in dried material, 1.5–1.9 mm long, glabrous; *tube* 0.6–0.8 mm long, mostly hyaline; *lobes* 0.8–1.2 mm long, 0.5–0.8 mm wide, acute to subacute. *Anthers* 0.2–0.3 mm long; free part of filaments 0.3–0.5 mm long. *Nectary scales* narrow elliptic to lanceolate, 0.3–0.7 mm long, 0.15–0.25 mm wide, acute to subacute. *Ovary* reddish (in rehydrated material), ovoid to ellipsoid, 0.8–1.1 mm long, 0.6–0.7 mm wide, textured by slightly raised elongated surface cells, 2-locular, style 0.1–0.2 mm long. *Fruit* dry and black in dried material, ovoid to ellipsoid, broadly ellipsoid to circular in cross-section, 1.0–1.3 mm long, 0.8–0.9 mm wide, smooth to finely textured by slightly raised elongated surface cells.

Specimens examined. WESTERN AUSTRALIA: 10 km due SSE of Mt Burdett, 2 Aug. 1983, *M.A. Burgman* 1635 *& S. McNee* (PERTH); 8.75 km due SE of Kau Rocks, 2.8 km SE of Mount Ney Road on Kau Rocks Road, 5 Sep. 1984, *M.A. Burgman & C. Layman* MAB 3531 (PERTH); Mallee Heath, 0.2 km SW of Tweedale Road on Muntz Road, Reserve 31799, Oct. 1984, *M.A. Burgman* 4300 (PERTH); 2 km W of Scaddan, 20 Aug. 1995, *R.J. Cranfield* 10202 (PERTH); N of Esperance, 4 Nov. 1901, *L. Diels* 5411 (PERTH); Lake Shaster Nature Reserve, off track running S from Springdale Road opposite Bedford Harbour Road, S of Munglinup, 26 Apr. 2008, *M. Hislop* 3761 (CANB, NSW, PERTH); 76.8 km E of Duke of Orleans Bay Road, 19 Sep. 1976, *R.J. Hnatiuk* 761032 (PERTH); *c.* 26 km SW of Israelite Bay and c. 160 km E of Esperance, 1 Oct. 1968, *E.N.S. Jackson* 1309 (AD, PERTH); 5 km E of Boyatup Hill, 11 Oct. 1983, *K. Newbey* 9796 (PERTH); Track to Point Malcolm, 4.5 km S of junction with Israelite Bay track, 29 Jul. 1986, *J.M. Powell* 2218 (DNA, NSW, PERTH); 2.6 km NW on Heywood Rd from junction with Karl Berg Rd, Esperance area, 5 Sep. 1986, *J.M. Powell* 2888 (NSW, PERTH, UNSW); 3 miles [*c.* 4.8 km] N of Gibson, 10 Aug. 1951, *R.D. Royce* 3573 (PERTH); 20 km E of Scaddan, 10 Sep. 1983, *P. van der Moezel* 290 (PERTH); 35 miles [*c.* 56.3 km] W of Esperance, 2 Sep. 1947, *J.H. Willis s.n.* (MEL); Approx. 48 km N of Esperance, 12 Sep. 1964, *P. Wilson* 3012 (AD, PERTH).

Distribution. Endemic to south-west Western Australia. Known from scattered locations between Scaddan and Point Malcolm, with an outlying western population near Lake Shaster (Figure 1).

Habitat. Available habitat information indicates that *D. oligarrhenoides* occurs on flat or slightly sloping terrain, sometimes near salt lakes, with deep, sandy soils, variously described as white, light grey or grey-brown, rarely with laterite present. *D. oligarrhenoides* occurs in heathland, tall scrub or very open shrub mallee. Associated dominants include species of *Banksia, Hakea, Grevillea, Melaleuca, Acacia* and mallee *Eucalyptus*.

Phenology. Flowering specimens have been collected between April and October.

Conservation status. A conservation nomination is presently considered unjustified, as a reasonable number of dispersed populations are known, including some with numerous plants. It occurs within Cape Arid National Park and other smaller conservation reserves.

Notes. Dielsiodoxa oligarrhenoides is readily distinguished by the presence of decussate leaves – a feature that is unique in the genus and is relatively uncommon in the Styphelioideae generally, where it is known in *Needhamiella* and some members of *Leucopogon* R. Br. *s.str.* and western '*Gynoconus*'. Although leaf venation is not apparent in *Dielsiodoxa oligarrhenoides*, cleared leaves show the typical *Dielsiodoxa* venation, though the veins (typically 5–7) are particularly broad in this species.

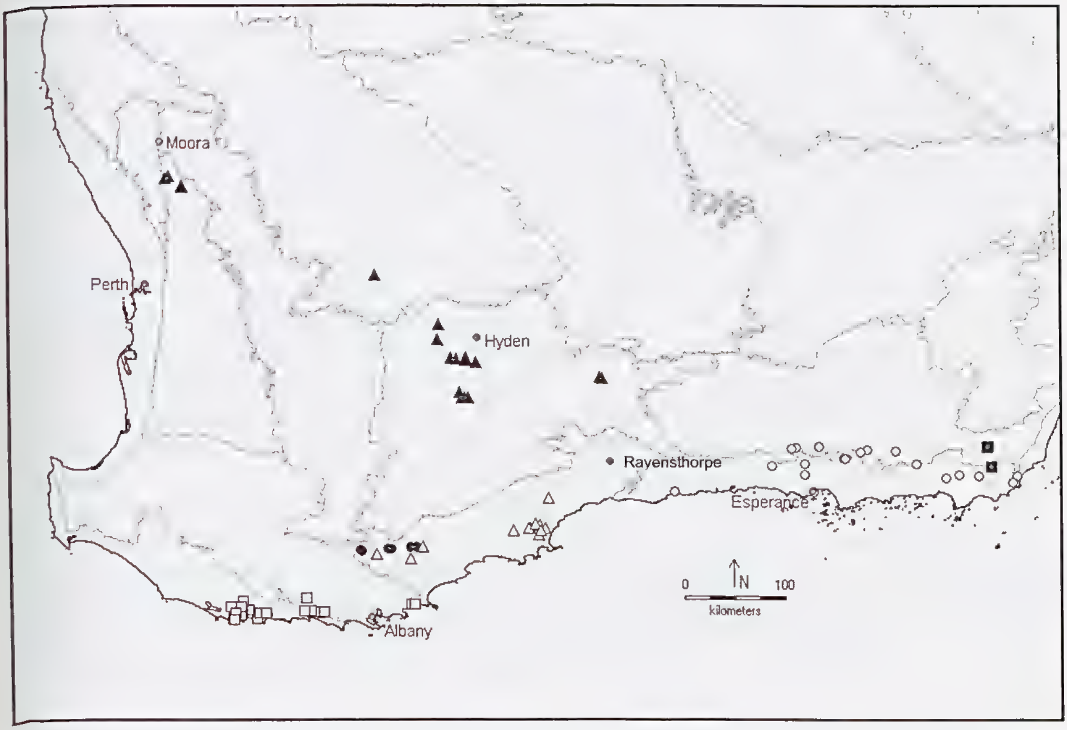


Figure 1. Distribution of *Dielsiodoxa leucantha* subsp. *leucantha* (▲), *Dielsiodoxa leucantha* subsp. *obtusa* (△), *Dielsiodoxa propullulans* (■), *Dielsiodoxa lycopodioides* (□), *Dielsiodoxa tamariscina* (●) and *Dielsiodoxa oligarrhenoides* (○) in Western Australia.

Blackall and Grieve (1981) misapplied the name *Monotoca oligarrhenoides*. The majority of specimens hitherto determined as *Monotoca oligarrhenoides* in Australian herbaria (probably largely based on Blackall and Grieve's concept) are *Dielsiodoxa propullulans*, and to a lesser extent *D. leucantha*, rather than *D. oligarrhenoides s.str.*

2. Dielsiodoxa tamariscina (F.Muell.) Albr., *Austral. Syst. Bot.* 23: 330 (2010). *Monotoca tamariscina* F.Muell., *Fragm.* 6: 79 (1867). *Styphelia minutiflora* F.Muell., *Fragm.* 11: 122 (1881). *Type*: In summis cacuminibus frigidiusculis montium Stirling's Ranges Australiae occidentalis inter rupes, [October 1867], *F. Mueller s.n.* (*lecto*, here designated: MEL 239718!; *isolecto*: MEL 239707!, MEL 239550!, MEL 2185965!, BM 001017993 digital image seen, K 000355600 digital image seen, K 000355602 digital image seen).

Illustration. W.E.Blackall & B.J.Grieve, *How to know W. Austral. Wildfl.* IIIB: 313 as *Monotoca tamariscina* (1981).

Erect to spreading densely branched *shrub c.* 0.1–0.5 (–1) m high. *Main stems and branches* grey to grey-brown, with longitudinally cracking persistent bark; *lateral branchlets* moderately fine, straight to somewhat curved, often entwined, grey-brown to brown, with an indumentum of spreading or variously orientated overlapping hairs 0.05–0.25 mm long, leaf abscission scars 0.2–0.4 mm wide. *Leaves* erect or ascending, sometimes appressed on main stems, helical, densely imbricate with *c.* 30–85 leaves per cm, variably persistent in dried specimens (sometimes only the terminal leaves retained), readily abscising when touched, lanceolate, narrowly elliptic, rhombic or ovate, 1.0–5.0 mm long, (0.3–)0.5–1.5 mm wide, those towards the distal ends of branchlets generally shorter and broader than those on the main stems, thin-textured, concave to plane adaxially in proximal half and more or less plane above, curved to saddle-shaped in longitudinal section, not keeled abaxially, adaxial and abaxial surfaces glabrous or with sparse short hairs, concolorous, 3–7 veins visible at least on the abaxial surface; margins sometimes with an extremely narrow hyaline fringe, minutely ciliolate-serrulate to ciliate with hairs to 0.4 mm long; apex not to strongly incurved, acute to acuminate, lacking a mucro. *Inflorescences* 1–3-flowered, borne on branchlets typically in a long fertile section, the axis of fertile branchlets usually continuing growth beyond the uppermost fertile nodes at anthesis, new growth sometimes also shooting from within fertile section of branchlet; *spike axis* 0.4–2.0 mm long including peduncle 0.1–0.6 mm long; *bracts* broadly rhomboid-ovate, often boat-shaped, 0.2–0.6 mm long, sterile proximal bracts absent or 1 or 2 present; *bracteoles* broadly rhomboid-ovate, 0.3–0.5 mm long, 0.2–0.4 mm wide. *Sepals* ovate, 0.3–0.8 mm long, 0.2–0.5 mm wide, apex acute or subacute. *Corolla* 5(–7)-lobed, mostly described as white in vivo at anthesis but label data also includes cream, creamy-yellow and greenish-white, presenting as brown post-anthesis in dried material, (1.0–)1.2–2.0 mm long, with short hairs to 0.1 mm long on the tube and at least on the proximal portion of external surface of the lobes; *tube* 0.4–1.0 mm long, mostly somewhat hyaline (most pronounced when fruiting); *lobes* 0.5–1.1 mm long, 0.2–0.5 mm wide, acute to subacute. *Anthers* 0.15–0.30 mm long; free part of filaments 0.3–0.6 mm long. *Nectary scales* narrow elliptic, lanceolate to narrowly oblong, 0.2–0.5 mm long, 0.05–0.20 mm wide, acute to obtuse. *Ovary* somewhat reddish (in rehydrated material), ovoid to ellipsoid, 0.6–1.2 mm long, 0.4–0.7 mm wide, textured by slightly raised longitudinally elongated surface cells, 2(3)-locular, style 0.1–0.2 mm long. *Fruit* dry and brownish-black in dried material, ovoid to ellipsoid, broadly ellipsoid to circular in cross-section, 1.1–1.3 mm long, 0.8-1 mm wide, finely textured as in ovary but not pustulate.

Other specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 6 Dec. 1994, *S. Barrett* 114 (PERTH); 7 Oct. 1994, *S. Barrett* 173 (PERTH); 7 Mar. 1995, *S. Barrett* 285 (PERTH); 23 Apr. 1923, *C.A. Gardner* 1427 (PERTH); 23 Apr. 1923, *C.A.Gardner* 1927 (PERTH);

11 Oct. 1928, *C.A. Gardner* 2195 (PERTH); Oct. 1928, *Gardner & Blackall s.n.* (PERTH); 12 Nov. 1961, *A.S. George* 3128 (PERTH); 7 May 1982, *S.D. Hopper* 2336 (CANB, K, PERTH); 24 Oct. 1985, *N. Hoyle* 1226 (PERTH); 11 May 1982, *G.J. Keighery* 4829 (PERTH); 2 Jul. 1957, *A.R. Main s.n.* (PERTH); 5 Oct. 1970, *B.R. Maslin* 1120 (PERTH); 25 Oct. 1985, *E. & S. Pignatti* 1551 (PERTH); 27 Oct. 1959, *R.D. Royce* 6059 (PERTH).

Distribution. Endemic to the Stirling Ranges in south-west Western Australia (Figure 1). All known populations are within Stirling Ranges National Park.

Habitat. Occurs in heathland or mallee heathland, mostly on quartzite mountain ranges. Most collections have been made from the higher parts of ranges (i.e. 1000 m altitude and above). Plants typically grow in rock crevices.

Phenology. Flowering specimens have been collected between October and December.

Conservation status. Recent field observations strongly indicate susceptibility to *Phytophthora cinnamomi* (Sarah Barrett pers. comm.). Given the active threat posed by *Phytophthora cinnamomi* and the small number of known populations, this species has been recently listed as Priority Two under the Department of Environment and Conservation (DEC) Conservation Codes for Western Australian Flora.

Typification. MEL 239718 has both flowers and fruit present and has been selected here as an appropriate lectotype.

There are some discrepancies between Mueller's protologue and the description presented here. Having examined all available material including a suite of specimens collected by Mueller (that includes the lectotype and isolectotypes), we believe that Mueller's protologue is in error with respect to the following features: presence of a narrow petiole, basally fused nectary scales and a 1-ovulate ovary.

Affinities. Blackall and Grieve (1981) had a broad species concept of *Monotoca tamariscina*, encompassing several taxa. Many specimens previously referred to *Monotoca tamariscina* are recognised in this treatment as *Dielsiodoxa lycopodioides*. Those specimens that are not *Dielsiodoxa lycopodioides* are either *D. tamariscina s. str.* or *D. leucantha* subsp. *obtusa*. *Dielsiodoxa tamariscina* differs from *D. lycopodioides* in having short hairs on the corolla tube and at least proximal part of corolla lobes externally (*cf.* glabrous in *D. lycopodioides*), non-pustulate ovary (*cf.* pustulate in *D. lycopodioides*) and larger fruits (1.1–1.3 mm long, *cf.* 0.8–1.0 mm long in *D. lycopodioides*).

Notes. Leaf shape, leaf indumentum and corolla size are rather variable in *D. tamariscina*.

Dielsiodoxa tamariscina occurs in the vicinity of *D. leucantha* subsp. *obtusa* and possibly *D. lycopodioides* (see notes under that species) in the central and eastern Stirling Ranges.

3. **Dielsiodoxa lycopodioides** Albr., *sp. nov.*

D. tamariscinae affinis sed corollis glabris, ovariis pustulatis, et fructibus parvioribus differt.

Typus: Mt Hopkins, Walpole-Nornalup National Park, Western Australia, 15 August 1979, *J.M. Powell* 1175 (*holo*: PERTH 03012530!; *iso*: AK *n.v.*, CANB!, CBG!, K *n.v.*, L *n.v.*, NSW!).

Monotoca sp. Walpole (B.J Lepschi 3666 & B.A.Fuhrer), Western Australian Herbarium, in *Florabase*, http://florabase.dec.wa.gov.au [accessed November 2010]; D.E.Albrecht, C.T.Owens, C.E.Weiller, & C.J.Quinn, *Austral. Syst. Bot.* 23: 320–332 (2010).

Illustration. J.Wheeler, N.G.Marchant & M.Lewington, *Fl. South West* 2: 606 (2002), as *Monotoca tamariscina.*

Erect to sprawling densely branched *shrub c.* 0.1–1.2(–2) m high. *Main stems and branches* grey-brown, with longitudinally cracking persistent bark; *lateral branchlets* fine, straight to somewhat curved, often entwined, grey-brown to brown, with an indumentum of mostly spreading hairs 0.05–0.10(–0.20) mm long, leaf abscission scars 0.10–0.35 mm wide. *Leaves* erect or ascending, sometimes appressed on main stems, helical, densely imbricate with *c.* 30–70 leaves per cm, typically few persisting in dried specimens (sometimes only the terminal leaves retained), readily abscising when touched, subulate, lanceolate, ovate or rarely narrowly rhombic, 0.8–5.2 mm long, 0.3–1.1 mm wide, (current seasons leaves with l:w ratio of 2–13:1) those towards the distal ends of branchlets generally shorter and broader than those on the main stems, thin-textured, concave to plane adaxially in proximal half and more or less plane above, curved to saddle-shaped in longitudinal section, not keeled abaxially, adaxial and abaxial surfaces glabrous or occasionally scabridulous on the adaxial surface, concolorous, 1–7 veins weakly visible at least on the abaxial surface; margins sometimes with an extremely narrow hyaline fringe, minutely ciliolate-serrulate with hairs to *c.* 0.2 mm long; apex incurved or straight, narrowly acute to acuminate, mucronulate or occasionally lacking a mucro. *Inflorescences* 1–3(4)-flowered, borne predominantly along the length of fine lateral branchlets, the axis of fertile branchlets often determinate but sometimes the upper ones continuing growth beyond the uppermost fertile nodes at anthesis, new vegetative growth apparently also shooting from upper axils of main stems; *spike axis* 0.4–2.0 mm long including peduncle 0.1–0.8 mm long; *bracts* broadly ovate to rhomboid-ovate, often boat-shaped, 0.2–0.5 mm long, sterile proximal bracts absent or 1–5 present; *bracteoles* broadly rhomboid-ovate, 0.25–0.40 mm long, 0.2–0.4 mm wide. *Sepals* ovate to ovate-elliptic, 0.4–0.8 mm long, 0.2–0.4 mm wide, apex acute. *Corolla* (4)5-lobed, apparently white, pale greenish-white or pale yellowish-green in vivo at anthesis, presenting as brownish post-anthesis in dried material, 1.0–1.5 mm long, glabrous; *tube* 0.5–0.7 mm long, mostly hyaline (most pronounced when fruiting); *lobes* 0.6–1 mm long, 0.3–0.5 mm wide, acute to subacute. *Anthers* 0.15–0.30 mm long; free part of filaments 0.25–0.45 mm long. *Nectary scales* narrow elliptic, lanceolate to narrowly oblong, 0.3–0.5 mm long, 0.05–0.10 mm wide, acute to obtuse. *Ovary* somewhat reddish (in rehydrated material), ovoid to ellipsoid, 0.6–0.8 mm long, 0.4–0.5 mm wide, minutely pustulate, 2-locular, style 0.1–0.2 mm long. *Fruit* dry and brownish-black in dried material, ovoid to broadly ellipsoid-globose, broadly ellipsoid to circular in cross-section, 0.8–1.0 mm long, 0.6–0.8 mm wide, minutely pustulate. (Figure 2)

Selected specimens examined. WESTERN AUSTRALIA: Walpole-Nornalup National Park, 17 Dec. 1985, *A.R. Annels s.n.* (PERTH); Between Albany and Denmark, *c.* 1.25 km W of Hay River bridge, 2 Sep. 1959, *Hj. Eichler* 16082 (AD, PERTH); 1.3 km along Pool Road from junction with Jones Road, 40 metres to N of road, 13 Feb. 1997, *P. Ellery & C. Godden* W 45.3 (PERTH); Rudyard, Wilsons Inlet, E of Denmark, 13 Jan. 1953, *R. Erickson s.n.* (PERTH); Near Boggy Lake, 6 m [*c.* 9.6 km] SW of Walpole, 2 Dec. 1956, *J.W. Green* 936 (PERTH); Coalmine Beach, Walpole-Nornalup National Park, 12 Aug. 1981, *W. Greuter s.n.* (NSW); Valley of the Giants Road, *c.* 14.5 km E of Walpole, 25 Oct. 1997, *B.J. Lepschi & B.A. Fuhrer* BJL 3666 (MEL, PERTH); 2.4 km W of Angrove Road / Centre Road intersection, 20 metres S of Centre Road, 13 Feb. 1997, *C. McChesney & C. Day* W 36.2 (PERTH); River flow meter area, 2 km NE of Break Rd junction on Denmark River, *c.* 15 km NW of Denmark, 1 Feb. 1980, *J.M. Powell* 1422 (MEL, NSW, PERTH); Mt Manypeaks, E ridge

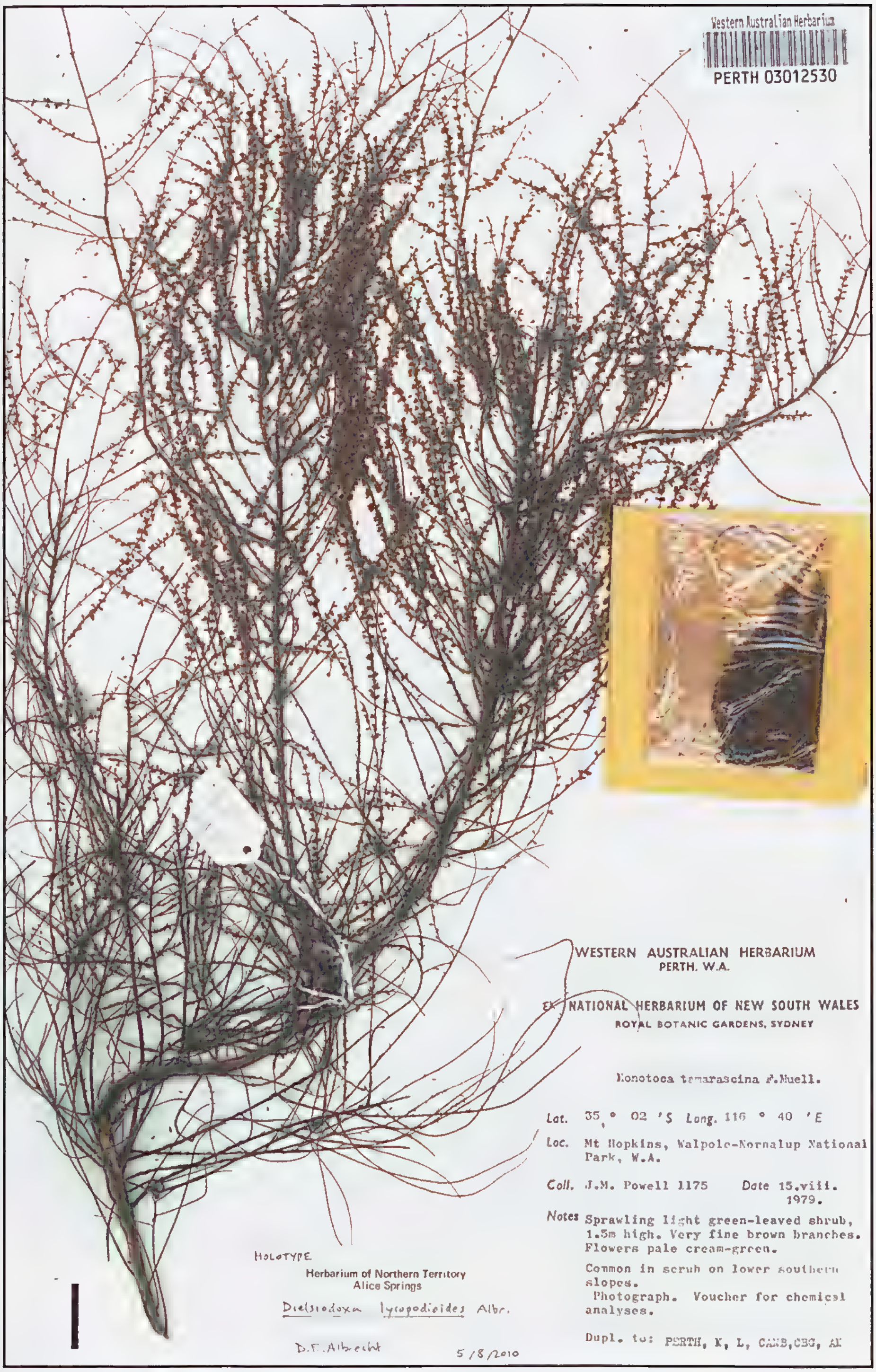

Western Australian Herbarium
PERTH 03012530
WESTERN AUSTRALIAN HERBARIUM
PERTH, W.A.
EX NATIONAL HERBARIUM OF NEW SOUTH WALES
ROYAL BOTANIC GARDENS, SYDNEY
Monotoca tamarascina F.Muell.
Lat. 35 ° 02 ' S Long. 116 ° 40 ' E
Loc. Mt Hopkins, Walpole-Nornalup National Park, W.A.
Coll. J.M. Powell 1175 Date 15.viii. 1979.
Notes Sprawling light green-leaved shrub, 1.5m high. Very fine brown branches. Flowers pale cream-green.
Common in scrub on lower southern slopes.
Photograph. Voucher for chemical analyses.
Dupl. to: PERTH, K, L, CANB, CBG, AK
HOLOTYPE
Herbarium of Northern Territory
Alice Springs
Dielsiodoxa lycopodioides Albr.
D.E. Albrecht
5/8/2010

Figure 2. Holotype of *Dielsiodoxa lycopodioides* Albr. (PERTH 03012530), scale = 2cm.

track and plateau area, 27 Aug. 1986, *J.M. Powell* 2662 (HO, NSW, PERTH); 4 miles [*c*. 6.4 km] W of Denmark, 17 Sep. 1966, *E.M. Scrymgeour* 1152 (PERTH); Approx. 1 Meile [mile = *c*. 1.6 km] W Denmark, 4 Nov. 1963, *H.U. Stauffer* 5376 *& R.D. Royce* (PERTH); Site 136, 7 km SW of Mount Frankland, 3 Sep. 1997, *D. Trenowden* 057 (PERTH); Deep River bridge between Walpole and Weld River, 13 Sep. 1963, *J.H. Willis s.n.* (MEL, PERTH).

Distribution. Endemic to south-west Western Australia. Collections have been made from three discrete areas centred on Walpole, Denmark and Mt Manypeaks (Figure 1). These places are amongst the wettest in south-west Western Australia.

Habitat. Occurs in a range of habitats including rocky hillsides, sandy, loamy or gravely flat terrain, and somewhat swampy areas. Associated vegetation is equally diverse floristically and structurally, including forest, woodland, shrubland, scrub and heathland. Frequently recorded associated taxa include *Eucalyptus marginata*, *Corymbia calophylla*, and species of *Agonis*, *Taxandria*, *Acacia*, *Allocasuarina* and *Pteridium*.

Phenology and reproductive biology. Flowering specimens have been collected between March and November. Keighery (1996: 352), based on observations made by J.S. Pate at Denmark, states that *Dielsiodoxa lycopodioides* [as *Monotoca tamariscina*] is pollinated by mosquitoes and tipulid flies.

Conservation status. A reasonable number of good sized populations are known and a conservation nomination is presently considered unjustified. However, the species has been noted [as *Monotoca tamariscina*] as susceptible to *Phytophthora cinnamomi* (Lyons 2008), and it is conceivable that populations could decline in the future. It occurs within Walpole-Nornalup National Park.

Etymology. The epithet indicates a superficial resemblance to some members of the family Lycopodiaceae.

Affinities. Dielsiodoxa lycopodioides as here defined was included under *Monotoca tamariscina* by Blackall and Grieve (1981). *Dielsiodoxa lycopodioides* is similar to *D. tamariscina* but differs in having glabrous corollas, minutely pustulate ovaries and smaller fruits. Although herbarium data indicates that *Dielsiodoxa lycopodioides* plants are variable in height, they are probably generally taller than *D. tamariscina*. A distinctive feature of *Dielsiodoxa lycopodioides* plants are their very fine branchlets.

Notes. Two specimens from the Stirling Ranges are tentatively placed here although they are not mapped in Figure 1. The material is poor and it has not been possible to confidently determine whether they are aberrant *Dielsiodoxa lycopodioides* or an undescribed taxon. These specimens—Stirling Ranges, 13 Nov. 1944, *R.J. Moir s.n.* (PERTH 03012484) and Bluff Knoll, Stirling Ranges, 12 Nov. 1961, *A.S.George 3127* (PERTH 02570408)—appear to be similar to *D. lycopodioides* but have a very short corolla tube and distinctly elongated papillae on the distal half of the ovary. Further fertile specimens including flowers and fruits are required to resolve the status of this material.

4. **Dielsiodoxa propullulans** Albr., *sp. nov.*

D. leucanthae affinis sed axe ramulorum fertilium sub anthesi.plerumque ultra nodis fertililibus supremis extenso et foliis latioribus inflorescentiis subtentis differt.

Typus: SW base of Mt Ragged Western Australia, 24 Nov. 1985, *A.N. Rodd* 5176 (*holo*: PERTH 01178369!; *iso*: NSW!).

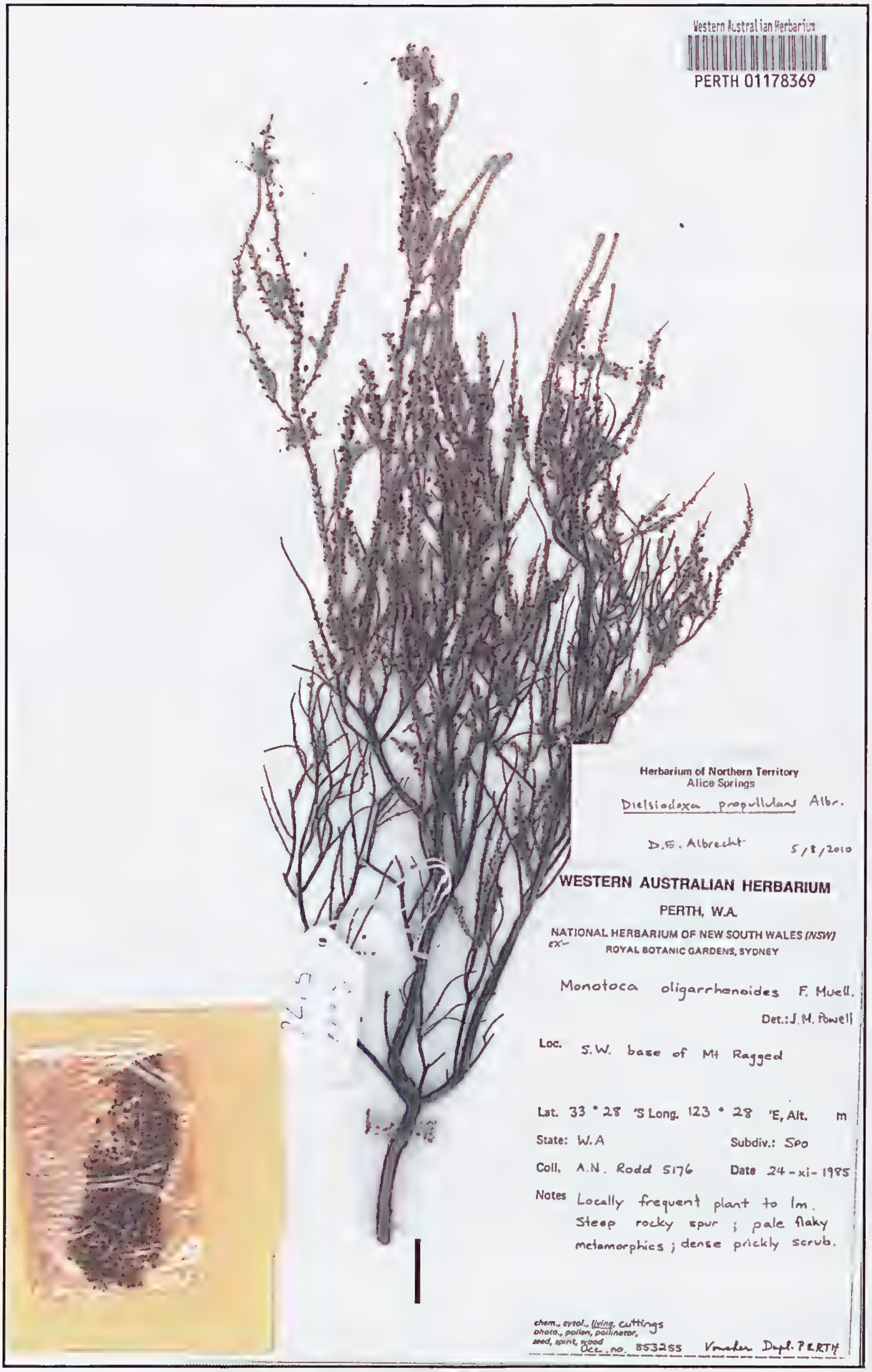
Monotoca sp. Mt Ragged (C.A. Gardner 2860), Western Australian Herbarium, in *Florabase* http://florabase.dec.wa.gov.au [accessed November 2010]; D.E.Albrecht, C.T.Owens, C.E.Weiller, & C.J.Quinn, *Austral. Syst. Bot.* 23: 320–332 (2010).

Dielsiodoxa oligarrhenoides auct. non (F.Muell.) Albr.: W.E.Blackall & B.J.Grieve, *How to know W. Austral. Wildfl.* IIIB: 313 (1981).

Illustration. W.E.Blackall & B.J.Grieve, *How to know W. Austral. Wildfl.* IIIB: 313 (1981) as *Monotoca oligarrhenoides*.

Erect multi-stemmed *shrub c.* 0.1–1 m high. *Main stems and branches* grey to grey-brown, with longitudinally cracking persistent bark; *lateral branchlets* moderately coarse, straight rarely curved, grey-brown to brown, with an indumentum of variously orientated overlapping hairs 0.05–0.10 mm long, leaf abscission scars 0.4–0.7 mm wide. *Leaves* erect, helical, densely imbricate with *c.* 30–50 leaves per cm, typically many persisting in dried specimens, readily abscising when touched, broadly ovate, depressed ovate or rarely broadly rhombic-elliptic, 1.3–3.0 mm long, 1.3–2.5 mm wide, (current seasons leaves with l:w ratio of 0.7–1.6:1), moderately thin-textured, concave adaxially in proximal half and more or less plane above, saddle-shaped in longitudinal section, not keeled abaxially, adaxial and abaxial surfaces glabrous, concolorous, 7–13 veins weakly visible at least on the abaxial surface; margins with an extremely narrow hyaline fringe, minutely ciliolate-serrulate, sometimes with longer hairs to 0.1mm long on lower margins; apex acute although sometimes appearing obtuse due to the hidden tip that is at right angles to the axis of the leaf, abruptly incurved, mucronulate or rarely lacking a mucro. *Inflorescences* 1–4(–6)-flowered, borne on branchlets in a comparatively long fertile section, the axis of fertile branchlets usually continuing growth beyond the uppermost fertile nodes at anthesis, new growth sometimes also shooting from within fertile section of branchlet; *spike axis* 0.7–2.0 mm long including peduncle 0.3–1.0 mm long; *bracts* ovate to rhomboid-ovate, often boat-shaped, 0.2–0.5 mm long, sterile proximal bracts absent or 1 or 2(–4) present; *bracteoles* broadly ovate to broadly rhomboid-ovate, 0.3–0.4 mm long, 0.2–0.4 mm wide. *Sepals* ovate to ovate-elliptic, 0.6–0.9 mm long, 0.4–0.5 mm wide, apex obtuse or subacute. *Corolla* 5-lobed, mostly described as white or cream in vivo at anthesis but label data also includes greenish-white or yellowish-green, presenting as brown post-anthesis in dried material, 1.4–2.0 mm long, glabrous; *tube* 0.5–0.8 mm long, mostly hyaline (most pronounced when fruiting); *lobes* 0.7–1.2 mm long, 0.4–0.6 mm wide, acute to subacute. *Anthers* 0.15–0.30 mm long; free part of filaments 0.3–0.6 mm long. *Nectary scales* narrowly lanceolate-deltoid to linear, 0.3–0.5 mm long, 0.05–0.15 mm wide, acute to obtuse. *Ovary* somewhat reddish (in rehydrated material), ovoid, ellipsoid or obovoid, 0.8–1.2 mm long, 0.5–0.7 mm wide, textured by slightly raised elongated surface cells, 2(3)-locular, style 0.1–0.2 mm long. *Fruit* dry and brownish-black in dried material, ovoid to broadly ellipsoid-globose, broadly ellipsoid to circular in cross-section, 1.1–1.4 mm long, 0.8–1.1 mm wide, almost smooth to textured by slightly raised elongated surface cells. (Figure 3)

Selected specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 6 Jan. 1979, *B. Barnsley* 289 (CANB, NSW); 16 Apr. 1995, *S. Barrett* 357 (PERTH); 10 Apr. 1974, *M.I.H. Brooker* B4512 (PERTH); 1 Jul. 1976, *D.J. McGillivray* 3620 *& A.S. George* (NSW, PERTH); 21 Sep. 2002, *P.M. Olde* 02/232 *& N. Marriott* (NSW); 30 Jul. 1986, *J.M. Powell* 2231 (NSW, PERTH); 30 Jul. 1986, *J.M. Powell* 2231A (NSW, PERTH); 24 Nov. 1985, *J.M. Powell* 3469 (NSW); 5 Dec. 1971, *R.D. Royce* 10112 (PERTH); 18 May 1967, *P.G. Wilson* 5850 (PERTH); 1 Nov. 1968, *J.W. Wrigley s.n.* (CANB, NSW).



Western Australian Herbarium
PERTH 01178369

Herbarium of Northern Territory
Alice Springs
Dielsiodoxa propullulans Albr.
D.E. Albrecht 5/8/2010

WESTERN AUSTRALIAN HERBARIUM
PERTH, W.A.
ex– NATIONAL HERBARIUM OF NEW SOUTH WALES *(NSW)*
ROYAL BOTANIC GARDENS, SYDNEY

Monotoca oligarrhenoides F. Muell.
Det.: J.M. Powell

Loc. S.W. base of Mt Ragged

Lat. 33 ° 28 'S Long. 123 ° 28 'E, Alt. m

State: W.A Subdiv.: Spo

Coll. A.N. Rodd 5176 Date 24-xi-1985

Notes Locally frequent plant to 1m. Steep rocky spur; pale flaky metamorphics; dense prickly scrub.

chem., cytol., living, cuttings
photo., pollen, pollinator,
seed, spirit, wood
Acc. no. 853255 Voucher Dupl. PERTH

Figure 3. Holotype of *Dielsiodoxa propullulans* Albr. (PERTH 01178369), scale = 2cm.

Distribution. Endemic to the Mt Ragged massif and The Diamonds Hill in south west Western Australia (Figure 1). All known populations occur within Cape Arid National Park.

Habitat. Occurs in heathland, low scrub or heathy mallee on rocky or gravely hills. Recorded as occurring on quartzite, granite and gneiss geologies, with sandy to loamy soils. Associated taxa include *Eucalyptus doratoxylon*, *E. tetraptera*, *Taxandria linearifolia*, *Banksia prolata* subsp. *archeos* and *Gastrolobium pycnostachyum*.

Phenology. Flowering specimens have been collected between March and August, and between October and January, but it probably flowers throughout the year if conditions are suitable.

Conservation status. Recently listed as Priority Two under DEC Conservation Codes for Western Australian Flora. Although currently locally common, the highly restricted distribution of this species may jeopardize its chances of survival if subjected to a significant threatening process, such as *Phytophthora cinnamomi*.

Etymology. The epithet derives from the Latin *propullulans* (shooting forth), and refers to the way in which the axis of fertile branchlets usually extends beyond the uppermost fertile nodes at anthesis.

Affinities. *Dielsiodoxa propullulans* is most similar to *D. leucantha*, the two differing in regard to the character of the leaves subtending the inflorescences and in the way new growth is initiated on fertile branchlets. *D. propullulans* has inflorescence-subtending leaves which are broadly ovate to depressed ovate, 1.5–2.2 mm wide and with an apex at right angles to the axis of leaf. In *D. leucantha* by contrast these leaves are broadly rhombic-elliptic to broadly rhombic-ovate, 0.6–1.5 mm wide and usually with the apex at an angle of 45 degrees or less relative to the leaf axis. And whereas *D. propullulans* usually has strong new growth continuing beyond the upper fertile nodes, in *D. leucantha* new growth issues from below the fertile section of the branchlet. The two species are allopatric with *D. propullulans* occurring more than 300 kilometres to the east of the easternmost known population of *D. leucantha*.

Notes. The name *Monotoca oligarrhenoides* was misapplied by Blackall and Grieve (1981) to specimens here treated as *Dielsiodoxa propullulans*.

5. **Dielsiodoxa leucantha** (E.Pritz.) Albr., *Austral. Syst. Bot.* 23: 330 (2010). *Monotoca leucantha* E.Pritz. in Diels & E.Pritz., *Bot. Jahrb. Syst.* 35: 480, fig. 53 (1904). *Type citation*: 'in distr. Avon septentrionali pr. Moore River in lapidosis montium "Babilon Hills" flor. m.', August [1901], *L. Diels* 4028 (*holo*: B, *n.v.*, presumably destroyed in WWII). *Neotype*: Babilion Hills, Mogumber, Western Australia, 25 September 1934, *C.A. Gardner s.n.* (*neotype,* here designated: PERTH 01244922!; *isoneotypes*: CANB!, K!, MEL!, NSW!).

Erect densely branched *shrub* 0.2–1.3 m high. *Main stems and branches* grey to grey-brown, with longitudinally cracking persistent bark; *lateral branchlets* moderately fine, straight to curved, grey-brown to brown, with an indumentum of variously orientated overlapping hairs 0.05–0.10 mm long, leaf abscission scars (0.3–)0.4–0.7 mm wide. *Leaves* erect, helical, densely imbricate with *c.* 24–50 leaves per cm, typically many persisting in dried specimens, readily abscising when touched, broadly rhombic-elliptic to broadly rhombic-ovate, 1.3–3.0 mm long, 0.9–1.7 mm wide, (current seasons leaves with l:w ratio of 1–2.1:1), moderately thin-textured, concave adaxially in proximal half and more or less plane above, saddle-shaped in longitudinal section, not keeled abaxially, adaxial and abaxial surfaces glabrous, concolorous, 7–11 veins usually weakly visible at least on the abaxial surface; margins usually with an extremely narrow hyaline fringe, minutely ciliolate-serrulate, sometimes with longer hairs to 0.1mm long on lower margins; apex acute to acuminate, almost straight to incurved, with the tip very occasionally at right angles to the axis of the leaf, lacking a mucro or mucronulate. *Inflorescences* 1–5-flowered, borne on branchlets in a distal fertile section, the axis of fertile branchlets not continuing growth beyond the uppermost fertile nodes at anthesis, or producing very short abortive growth, new growth more often shooting from below fertile section of branchlet; *spike axis* 0.7–2.5 mm long including peduncle 0.3–1.0 mm long; *bracts* ovate to rhomboid-ovate, often boat-shaped, 0.1–1.0 mm long, sterile proximal bracts typically 2, rarely only 1 or 3–5 present; *bracteoles* ovate to depressed ovate, 0.3–0.8 mm long, 0.3–0.6 mm wide, acute to obtuse. *Sepals* ovate-elliptic, ovate, broadly ovate to almost orbicular, 0.5–1.1 mm long, 0.30–0.65 mm wide, acute to obtuse. *Corolla* 5-lobed, white to cream in vivo at anthesis (rarely recorded as pale yellow), presenting as brown post-anthesis in dried material, 1.5–2.1 mm long, glabrous; *tube* 0.5–1.0 mm long, mostly hyaline (most pronounced when fruiting); *lobes* 0.9–1.3 mm long, 0.5–0.8 mm wide, acute to subacute. *Anthers* 0.15–0.40 mm long; free part of filaments 0.3–0.8 mm long. *Nectary scales* narrowly elliptic, lanceolate, oblong, oblanceolate or obovate, 0.25–0.70 mm long, 0.10–0.25 mm wide, acute to obtuse, sometimes bilobed. *Ovary* somewhat reddish (in rehydrated material), ovoid to ellipsoid, 0.8–1.2 mm long, 0.5–0.7 mm wide, textured by slightly raised elongated surface cells, 2-locular, style 0.1–0.2 mm long, stigma cleft 0.02–0.18 mm deep. *Fruit* dry and brownish-black in dried material, ovoid to broadly ellipsoid, circular in cross-section, 1.0–1.4 mm long, 0.6–1.0 mm wide, almost smooth to textured by slightly raised elongated surface cells.

Typification. Specimens of Ericaceae subf. Styphelioideae were apparently among those that were completely destroyed by the bombing raids of Berlin during the Second World War (Botanical Museum Berlin-Dahlem 1999). According to Stafleu and Cowan (1976), Diels' Australian specimens are also housed at BM, CANB and MEL. An attempt to relocate type material at these institutions has proven unfruitful. Although the protologue includes an excellent illustration we have opted to designate a specimen as the neotype rather than rely solely on the illustration. The neotype is from the same small range of hills as the holotype and conforms well with the protologue.

Affinities. In general appearance *Dielsiodoxa leucantha* resembles *D. oligarrhenoides* but is readily distinguished by the strictly helical, rather than mostly decussate, leaf arrangement. It shares a number of features with *Dielsiodoxa propullulans*, differing in the shape, width and apex of leaves subtending the inflorescence and the way new growth is initiated on fertile branchlets. These differences are presented in detail under *D. propullulans*.

Two geographically separated subspecies are recognised.

Dielsiodoxa leucantha (E.Pritz.)Albr. subsp. **leucantha**

Illustrations. Diels & E.Pritz, *Bot. Jahrb. Syst.* 35: 480–481 (1904) as *Monotoca leucantha*; W.E.Blackall & B.J.Grieve, *How to know W. Austral. Wildfl.* IIIB: 313 (1981) as *Monotoca leucantha.*

Bracteoles usually acute or subacute, rarely obtuse, ovate to broadly ovate (usually longer than wide) 0.4–0.7 (–0.8) mm long. *Sepals* usually acute or subacute, occasionally obtuse 0.7–1.1 mm long. *Corolla tube* (0.65–)0.75–1.0 mm long. *Nectary scales* variously shaped from oblong, lanceolate, oblanceolate to narrowly elliptic, (0.3–)0.45–0.70 mm long. *Stigma cleft* 0.05–0.18 mm deep.

Selected specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 16 Sep. 1992, *B. & B. Backhouse* BM168 (PERTH); 29 Apr. 1994, *R.M. Buehrig* 94.04.29 (10) (PERTH); 9 Sep. 1996, *A.M. Coates, R. Cugley, E. Bishop & J. Stewart* 4418 (CANB, PERTH); 12 Oct. 2003, *D.M. Crayn* 723 (K, NSW, NYBG, PERTH, WFU); 14 Nov. 1990, *E.A. Griffin* 6150 (PERTH); 3 Sep. 1970, *K.R. Newbey* 3351 (PERTH).

Distribution. Endemic to south-west Western Australia. This taxon has an unusual and rather anomalous distribution comprising two very disjunct population nodes—a small western one near Mogumber (south of Moora), and a larger eastern occurrence centred to the east and south-east of Hyden. The eastern node itself has a couple of outlying populations near Bruce Rock and Hatters Hill (Figure 1). This subspecies has the most northerly and inland distribution of any member of the genus.

Habitat. Populations occur in open woodland, heathland or open shrub mallee and are usually associated with breakaways, often with white soils and quartz and/or lateritic gravel.

Phenology. Flowering specimens have been collected between July and October.

Conservation status. Dielsiodoxa leucantha is currently listed as Priority Three under DEC Conservation Codes for Western Australian Flora (Smith 2010), under the name *Monotoca leucantha*. Although there is no obvious justification for maintaining either subspecies on the Priority List, the situation in relation to the typical subspecies is complicated by the fact that, as circumscribed here, the latter comprises two forms which are widely separated geographically. The western or type form, is currently known from just two populations, only one of which is protected in the Conservation Estate. The only significant difference between it and the eastern form appears to be that it has narrower corolla lobes and there is also a tendency to larger leaves. The authors felt that, in the absence of other data, this morphological basis was inadequate for the recognition of another taxon. However, although apparently slight, the corolla difference is consistent. In these circumstances, because of the conservation implications, it would be desirable to utilize molecular sequence data to investigate relationships between the different forms of this subspecies (and including subsp. *obtusa*), in order to assess whether the classification used here requires modification. Following the precautionary principle, until such time as a study of this kind can be undertaken, this taxon will remain Priority 3.

Dielsiodoxa leucantha (E.Pritz.) Albr. subsp. **obtusa** Hislop & Albr., *subsp. nov.*

D. leucanthae subsp. *leucanthae* affinis sed bracteolis et sepalis obtusis, sepalis, tubo corollae et squamis nectarii brevioribus differt.

Typus: Fitzgerald River National Park, Mount Maxwell, track to lookout, Western Australia, 16 July 2010, *C. Puente-Lelièvre & E.A. Brown* CPL 93 (*holo*: PERTH 08228655!; *iso*: MEL!, NSW!).

Monotoca leucantha subsp. Stirling Range (D.M. Crayn 80); D.E.Albrecht, C.T.Owens, C.E.Weiller, & C.J.Quinn, *Austral. Syst. Bot.* 23: 320–332 (2010).

Bracteoles usually obtuse, rarely subacute, broadly ovate to depressed-ovate (usually shorter than wide), 0.30–0.50 (–0.55) mm long. *Sepals* usually obtuse, occasionally subacute, 0.50–0.75 (–0.85) mm long. *Corolla tube* 0.5–0.8 mm long. *Nectary scales* obovate to oblong-obovate, 0.25–0.40 (–0.55) mm long. *Stigma cleft* 0.02–0.10 mm deep. (Figure 4)

Selected specimens examined. WESTERN AUSTRALIA: Bell Track ca 4.5 km S of northern (internal) fireline, 24 Mar. 2004, *S. Barrett* 1212 (PERTH); Stirling Range National Park, Hosteller Hills, 21 Jun. 2007, *S. Barrett* 1613 (PERTH); 30m along trail to Pillenorup Swamp after entering Stirling Range National Park on Chester Pass Rd from the South, 2 Oct. 1995, *D.M. Crayn* 68 (UNSW); Fitzgerald River National Park, 1–2 km N of Quaalup, 19 Oct. 1991, *W. Greuter* 22985 (PERTH); Ridgeline below Ellen's Peak, SW Stirling Ranges, 11 May 1982, *G.J. Keighery* 4938 (PERTH); Mt Bland, 6 Apr. 1963, *K.R. Newbey* 734 (PERTH); Mt Maxwell, slopes below summit, 17 Nov. 1985, *J.M. Powell* 3336 (NSW, PERTH); West Mt Barren, 18 Nov. 1985, *J.M. Powell* 3363 (NSW, PERTH, HO).

Distribution. Endemic to south-west Western Australia, where it is apparently confined to the Fitzgerald River and Stirling Ranges National Parks (Figure 1). Its distribution lies well to the south of the typical subspecies.

Habitat. Occurs in heathland or mallee heath, usually on hillslopes with stony or rocky sandy (rarely peaty-sand) soils. Recorded once on a flat depression with deep white sand. Occurs in the vicinity of *Dielsiodoxa tamariscina* in the eastern Stirling Ranges.

Phenology. Flowering specimens have been collected between March and September.

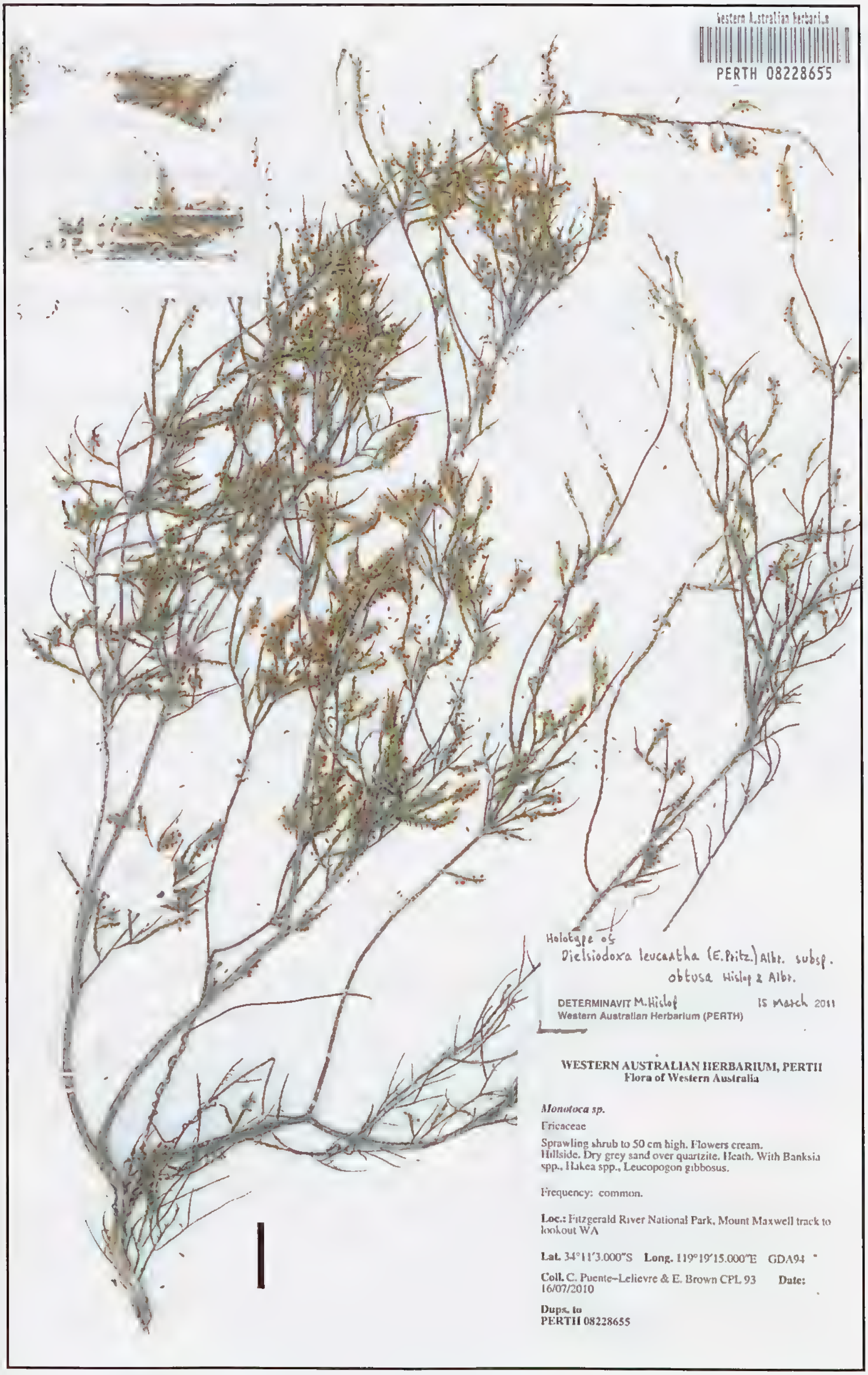
Conservation status. This taxon is locally common in the Fitzgerald River National Park and no conservation code is recommended here. However, because it is very likely to be susceptible to *Phytophthora cinnamomi* its status may need to be reviewed as that pathogen inevitably spreads within the park.

Etymology. The epithet refers to the obtuse bracteoles and sepals.

Notes. Because of limited overlap in most of the characters used to separate this taxon from typical *D. leucantha*, the rank of subspecies was considered the most appropriate to apply. However the two taxa are generally easily distinguished from each other, subsp. *obtusa* differing in its shorter usually obtuse bracteoles and sepals, shorter corolla tube, shorter and broader nectary scales, and less deeply cleft stigma. In addition there are potential differences in habit and phenology that need further investigation. As suggested above a molecular study of infraspecific relationships within *D. leucantha* would be particularly valuable and may indicate that subsp. *obtusa* is better treated as a separate species.

Acknowledgements

We thank the directors of CANB, MEL, NSW, PERTH and UNSW for loan of specimens and access to their collections. John Hunnex (BM) and Clare Drinkell (K) kindly checked collections at their herbaria and sent digital images of potential types. Neville Walsh, Graham Bell and Brendan Lepschi checked for types at MEL, AD and CANB respectively. Paul Wilson provided nomenclatural advice and prepared the Latin diagnoses, and Juliet Wege prepared the distribution map. Rob Davis, Sarah Barrett and Mavis Sowry kindly went out of their way to collect DNA samples of *Dielsiodoxa*. We also acknowledge Chris Quinn's invaluable support and Kevin Thiele's assistance in facilitating the completion of this work.



Western Australian Herbarium
PERTH 08228655

Holotype of
Dielsiodoxa leucantha (E.Pritz.) Albr. subsp.
obtusa Hislop & Albr.

DETERMINAVIT M.Hislop 15 March 2011
Western Australian Herbarium (PERTH)

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Monotoca sp.

Ericaceae

Sprawling shrub to 50 cm high. Flowers cream.
Hillside. Dry grey sand over quartzite. Heath. With Banksia spp., Hakea spp., Leucopogon gibbosus.

Frequency: common.

Loc.: Fitzgerald River National Park, Mount Maxwell track to lookout WA

Lat. 34°11'3.000"S **Long.** 119°19'15.000"E GDA94

Coll. C. Puente-Lelievre & E. Brown CPL 93 **Date:** 16/07/2010

Dups. to
PERTH 08228655

Figure 4. Holotype of *Dielsiodoxa leucantha* subsp. *obtusa* Hislop & Albr. (PERTH 08228655), scale = 2 cm.

References

Albrecht, D.E., Owens, C.T., Weiller, C.E. & Quinn, C.J. (2010). Generic concepts in Styphelieae: the *Monotoca* group. *Australian Systematic Botany* 23: 320–332.

Bell, T.L. (1995). *Biology of Australian Epacridaceae: with special reference to growth, fire response and mycorrhizal nutrition.* PhD thesis, Department of Botany, University of Western Australia, p 251.

Bell, T.L., Pate, J.S. & Dixon, K.W. (1996). Relationships between fire response, morphology, root anatomy and starch distribution in south-west Australian Epacridaceae. *Annals of Botany* 77: 357–364.

Blackall, W.E. & Grieve, B.J. (1981). *How to know Western Australian wildflowers.* Part IIIB, 2nd edn. (University of Western Australia Press: Nedlands, WA.)

Botanical Museum Berlin-Dahlem (1999). *List of families including extant collections of the Botanical Museum Berlin-Dahlem (B) from the time before 1943.* http://www.bgbm.fu-berlin.de/BGBM/research/colls/herb/phanerog.htm [accessed January 2011]

Diels, L. & Pritzel, E (1904). Fragmenta phytographiae Australiae Occidentalis. *Botanische Jahrbucher* 35: 480–481.

Keighery, G.J. (1996). Phytogeography, biology and conservation of Western Australian Epacridaceae. *Annals of Botany* 77: 347–355.

Lyons, M. (2008). *A study into the risk of Phytophthora dieback in Ten Peri-urban Reserves within the Shire of Denmark.* (Project Dieback: Perth.)

Smith, M.G. (2010). *Declared Rare and Priority Flora List for Western Australia.* (Dept of Environment and Conservation: Kensington, WA.)

Stafleu, F.A. & Cowan, R.S. (1976). *Taxonomic literature.* Vol. 1. 2nd ed. (Bohn, Scheltema & Holkema: Utrecht.)

Stuppy, W. (2004). *Glossary of seed and fruit morphological terms.* (Seed Conservation Department, Royal Botanic Gardens: Kew, England.)

Wheeler, J., Marchant, N. & Lewington, M. (2002). *Flora of the south west: Bunbury-Augusta-Denmark.* Vol 2, Dicotyledons. (Australian Biological Resources Study: Canberra.)

Sida picklesiana (Malvaceae), a new species from the Murchison-Gascoyne region of Western Australia

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Abstract

Markey, A.S., Dillon, S.J., Cockerton, G.T.B. & Barker, R.M. *Sida picklesiana* (Malvaceae), a new species from the Murchison-Gascoyne region of Western Australia. *Nuytsia* 21(3): 127–137 (2011). This article provides a description of the recently discovered species *Sida picklesiana* A.S.Markey, S.J.Dillon & R.M.Barker. This species is known from an area near Wiluna in Western Australia's Murchison-Gascoyne region, where it occurs in a variety of habitats. *Sida picklesiana* has conservation priority status as it has a relatively limited distribution. Major differences between *S. picklesiana* and the species with which it is most likely to be confused are discussed, and the most recently published draft key to *Sida* is amended to include this new species.

Introduction

The genus *Sida* L. (Malvaceae) is a common and diverse component of the flora of central Australia. It is also a taxonomically problematic group, and nearly half of the 62 taxa recognized in Western Australia are currently undescribed (Western Australian Herbarium 1998–). Barker (2007) produced a draft key to Western Australian species of *Sida s. lat.* as part of an ongoing revision of the genus. *Sida picklesiana* was unknown at that time, and is described here as a new species from the Murchison and Gascoyne regions of Western Australia.

Recent vegetation surveys of Banded Iron Formation (BIF) ranges in the Midwest region of Western Australia by the Department of Environment and Conservation (DEC) have found a number of previously unknown species (Gibson *et al.* 2007, Wege *et al.* 2007). One such survey near the township of Wiluna located a population of an unusual *Sida,* and specimens were found to have a combination of characters that did not match any taxon represented in the collections of the Western Australian Herbarium (Markey & Dillon 2009). The floral and vegetative characters were distinctive enough to immediately recognise this as a new entity, and later to assign it the interim phrase name of *Sida* sp. Wiluna (A. Markey & S. Dillon 4126). Unknown to these authors at that time, several populations of a distinctive *Sida* had also been located by G. Cockerton near Mt Keith (*c.* 40 to 65 km south of the Wiluna populations). Examination of fertile material determined that these populations were southern variants of *Sida* sp. Wiluna (A. Markey & S. Dillon 4126).

Formal recognition of *Sida picklesiana* A.S.Markey, S.J.Dillon & R.M.Barker was delayed by a lack of fruiting collections in these initial surveys, as both the schizocarp and fruiting calyx provide diagnostic features in *Sida* (Barker 2007). Recent surveys located both mature fruits and several new populations, allowing for both this entity to be formally described and an amendment to the key for Western Australian *Sida s. lat.* (Barker 2007) to be given in this paper.

Methods

This study was based on an examination of specimens of *Sida* species lodged at the Western Australian Herbarium (PERTH) and the State Herbarium of South Australia (AD). Close comparisons were made of material from species that were similar in appearance, notably from *Sida* sp. dark green fruits (S. van Leeuwen 2260), *S. ectogama* W.R.Barker & R.M.Barker, *S. petrophila* F.Muell., *S. calyxhymenia* DC. and *S.* sp. Petermann Ranges (B.G. Thomson 2340). Informal phrase names cited in this paper are listed on the census of Western Australian plants database of the Western Australian Herbarium (1998–).

Observations and measurements of fruit and vegetative characters were made from dried and wet (70% ethanol) herbarium specimens. Dried flowers were rehydrated for observations, measurements and sectioning. Descriptive terminology follows Barker (2007). Herbarium notes on habit and habitat were supplemented by field observations. A distribution map was generated from herbarium records (PERTH) using DIVA–GIS freeware version 5.0 (http:/www.diva_gis.org/).

Taxonomy

Sida picklesiana A.S.Markey, S.J.Dillon & R.M.Barker, *sp. nov.*

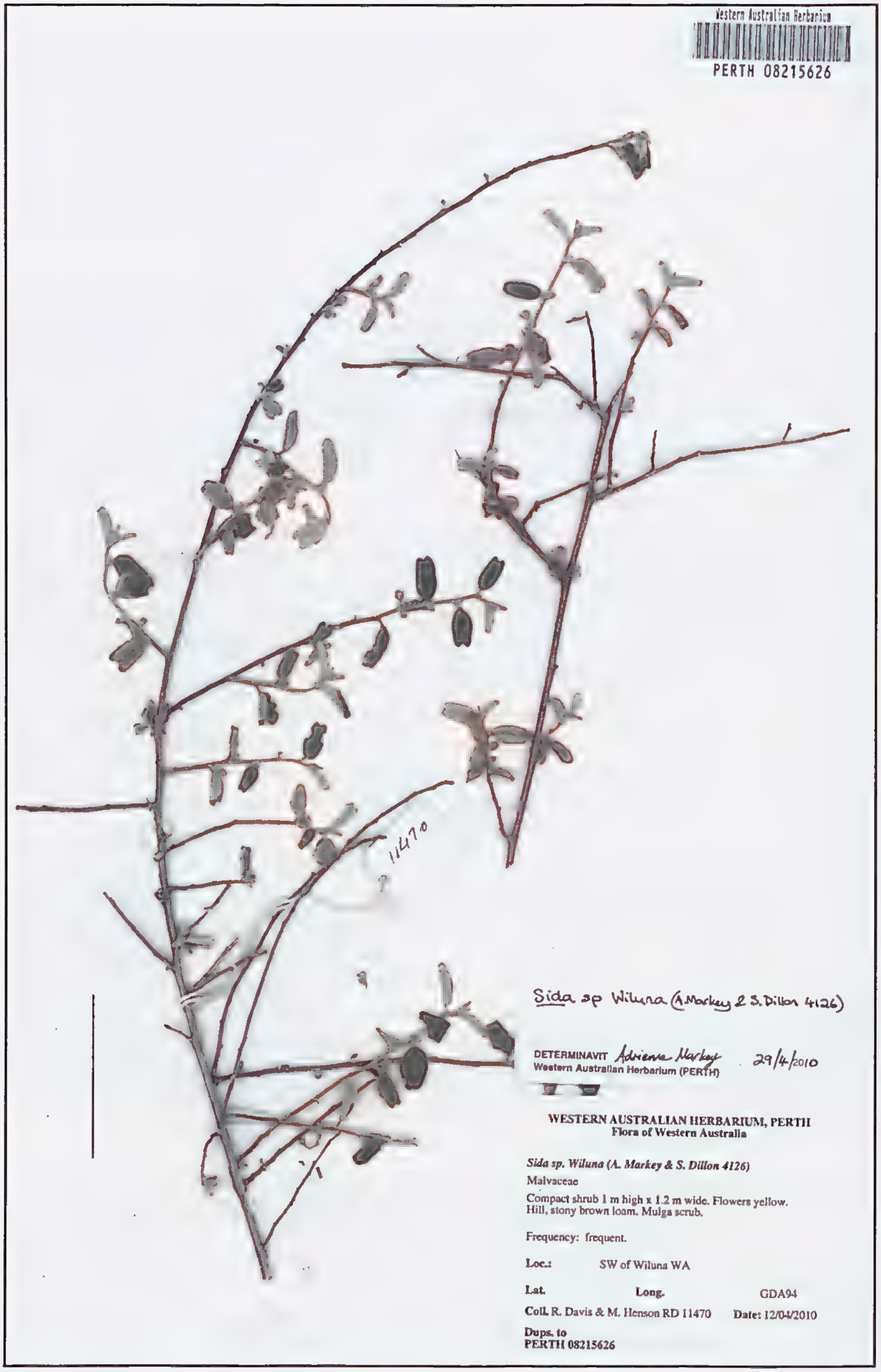
Foliis discoloris et plantis dioeciis S. ectogamae W.R.Barker & R.M.Barker similis, praecipue differt floribus parvioribus subsessilibus, calycis lobis non-accrescentibus, marginibus foliorum integris (non-crenulatis), et columna stamineali glabra.

Typus: south-west of Wiluna, Western Australia [precise locality withheld for conservation reasons], 12 April 2010, R. Davis & M. Henson RD 11470, with female flowers and fruit (*holo*: PERTH 08215626; *iso*: AD); 12 April 2010, R. Davis & M. Henson RD 11471b, with male flowers and fruit (*topo*: AD, PERTH 07984022).

Sida sp. Wiluna (A. Markey & S. Dillon 4126), Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au/ [accessed January 2011].

Woody perennial shrub, 0.4–1.0(–1.5) m high and 0.8–1.0(–1.2) m wide, compact, rounded, densely branched, twiggy; root morphology and regenerative capacity from rootstock unknown. *Branches* divaricate, more densely so when browsed, densely pubescent when young, glabrescent and becoming weathered, scurfy and grey with age; branchlets sometimes clustered in dense fascicles, rounded; leaf abscission scars present; bark smooth, minutely fissured with age. *Indumentum* in all parts of sessile to shortly stipitate, eglandular, stellate, colourless or white to golden-yellow hairs. *Leaves* alternate, distinctly discolorous, petiolate; petiole 1–3(–4) mm; lamina ovate or oblong to narrowly ovate-oblong or depressed obovate, (5–)10–20(–40) × (3–)4–8(–11) mm, usually 4–9 times petiole length, sometimes folded such that upper two halves of the blade are appressed to each other; base rounded; margin entire or occasionally with 1–2 pairs of serrations; apex truncate or emarginate, often with midrib extended by *c.* 0.5 mm; adaxial surface dark olive green, often aging to brown-red, with dense indumentum of colourless, sessile stellate hairs 0.1–0.2(–0.3) mm in diameter, the rays appressed to slightly ascending; abaxial surface and leaf margins pale golden-yellow or pale green with indumentum of very dense, white to golden-yellow, sessile to shortly stipitate stellate hairs 0.3–0.5(–0.6) mm in diameter, the rays ascending to erect; venation reticulate, obscured above, raised below. *Stipules* in pairs at petiole base, usually only present on younger growth but scars visible on older growth, linear to subulate-linear, 0.5–3.6(–4.0) mm long, the indumentum as on petiole and lamina but apex glabrescent. *Flowers* subsessile, axillary, solitary or paired in leaf axils of newer growth, unisexual on generally dioecious plants (occasional fruits from female flowers observed on male plants). *Buds* ellipsoid to subglobose, faintly 5 grooved at apex, erect. *Pedicels* 0.4–3.0(–3.6) mm long in flower, 0.8–3.0 mm long in fruit, with dense, sessile, white to golden stellate hairs, basally articulate. *Calyx* (3–)4–5 mm long, synsepalous with five lobes, lobed to middle third, broadly cupular in open flower, persistent in fruit, non-accrescent, without longitudinal striations, abaxial surface stellate-hairy, adaxial surface of tube glabrous, of lobes with puberulous hairs, loosely enclosing base of schizocarp; lobes broadly triangular with acute to acuminate apex, 1.3–2.7 mm long, 1.2–2.3 mm wide at base. *Corolla* yellow, glabrous, just exceeding calyx; (4.0–)5.0–8.0 mm in diameter; claw 0.2–0.5 mm long, ciliate; lobes spathulate, obtuse–emarginate apically, 1.8–3.5(–4.5) mm long, 1.7–3.0 mm wide at widest part, non-ciliate. *Stamens* 20(–23) per flower; filaments connate into a tube around the styles for much of their length; free parts arranged regularly at apex, all equal, 0.8–1.1 mm long in male flowers, 0.1–0.2 mm long in female flowers; staminal column 1.5–2.3 mm long in male flowers, 1.1–1.2 mm long in female flowers, glabrous; anthers in male flowers all fertile, scarcely exserted from the corolla, 0.5–0.8 mm long, reniform, versatile, longitudinally dehiscent by single top suture; pollen yellow; sterile anthers in female flowers much smaller, 0.3–0.4 mm long. *Styles* 5(6), in female flowers 2.2–2.8 mm long, exserted 1.0–1.5 mm beyond staminal column and stamens and just exserted from flower; stigma discoid; styles in male flowers rudimentary and remaining enclosed within the base of the staminal column, 0.4–0.9 mm long and 1/3–1/2 length of staminal column. *Ovary* 0.5–1.0 mm high, 1.0–1.2 mm wide, ovules 5(6), appearing fully developed in male flowers. *Schizocarp* 3.2–4.7 mm diameter, 3.0–4.0 mm high, regular or rarely irregular due to unequal development of mericarps, depressed-ovoid–transversely ellipsoid, raised at centre, green when immature, light brown at maturity, shallowly grooved between mericarps; *mericarps* 5(6), 3.0–3.6 mm high, 1.5–2.2 mm wide, all regular, trigonous, indehiscent, grooved at apex, separating at maturity from each other and columella; dorsal (exposed) surface unornamented, smooth or slightly rugose, with a dense indumentum of minute, short, sessile, stellate hairs; lateral walls (internal faces) prominently reticulate; columella, pedicel and calyx persistent on plant after shedding of mericarps, eventually separating from the branch with age. *Seed* one per mericarp, 2.2 mm long, 1.5 × 1.5 mm wide, trigonous with obtuse outer surface, light brown; surface smooth, villous, with an indumentum of simple, eglandular hairs. (Figures 1–3)

Selected specimens examined. WESTERN AUSTRALIA: [localities withheld for conservation reasons] 14 Oct. 2010, *G. Cockerton & C. Jowett s.n.* (PERTH); 4 Nov. 2010, *G. Cockerton, D. Brassington & S. Colwill* LCH 29854 (PERTH); 12 Apr. 2010, *R. Davis & M. Henson* RD 11465 (PERTH); 12 Apr. 2010, *R. Davis & M. Henson* RD 11467 (PERTH); 12 Apr. 2010, *R. Davis & M. Henson* RD 11470 (PERTH); 13 Apr. 2010, *R. Davis & M. Henson* RD 11469 (PERTH); 14 Apr. 2010, *R. Davis & M. Henson* RD 11471a (PERTH); 14 Apr. 2010, *R. Davis & M. Henson* RD 11471b (PERTH); 4 Aug. 2010, *R. Davis & M. Henson* RD 11480 (PERTH); 4 Aug. 2010, *R. Davis & M. Henson* RD 11476 (PERTH); 27 Aug. 2006, *D.J. Edinger* 5375 (PERTH); 20 Aug. 2006, *A. Markey & S. Dillon* 4126 (AD, PERTH); 20 Aug. 2006, *A. Markey & S. Dillon* 4306 (PERTH); 21 Aug. 2006, *A. Markey & S. Dillon* 4305 (PERTH); 21 Aug. 2006, *A. Markey & S. Dillon* 4127 (AD, PERTH); 8 Dec. 1995, *A.A. Mitchell* 4149 (PERTH).



Sida sp Wiluna (A.Markey & S.Dillon 4126)

DETERMINAVIT Adrienne Markey 29/4/2010
Western Australian Herbarium (PERTH)

WESTERN AUSTRALIAN HERBARIUM, PERTH
Flora of Western Australia

Sida sp. Wiluna (A. Markey & S. Dillon 4126)
Malvaceae
Compact shrub 1 m high x 1.2 m wide. Flowers yellow.
Hill, stony brown loam. Mulga scrub.

Frequency: frequent.

Loc.: SW of Wiluna WA

Lat. Long. GDA94

Coll. R. Davis & M. Henson RD 11470 Date: 12/04/2010

Dups. to
PERTH 08215626

Figure 1. Holotype of *Sida picklesiana* (*R. Davis & M. Hensen* 11470), with precise locality obfuscated. Scale bar = 5 cm.

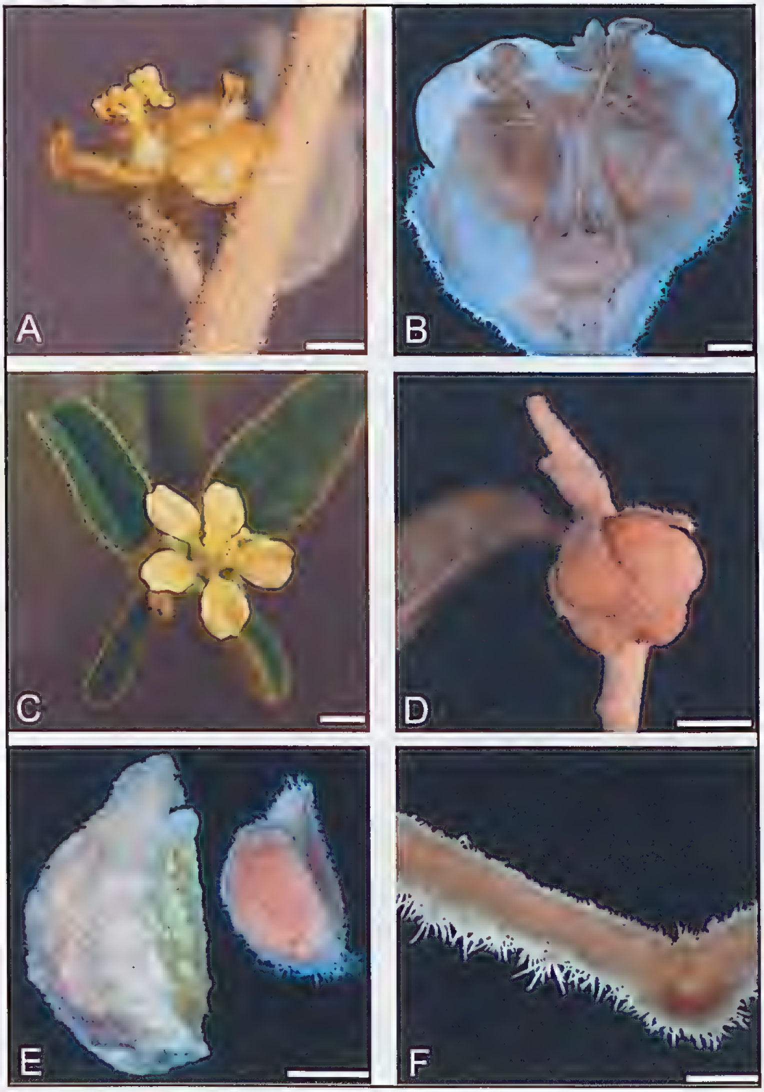


Figure 2. *Sida picklesiana.* A – male flower (scale = 2.0 mm); B – rehydrated male flower sectioned to show the ovary and degenerate style (scale = 0.5 mm) (*R. Davis & M. Henson* RD 11471b); C – female flower (scale = 2.0 mm); D – fruit preserved in ethanol (scale = 2.4 mm) (*R. Davis & M. Henson* RD 11469); E – mericarp and seed (scale = 1.0 mm) (*R. Davis & M. Henson* RD 11469); F – transverse section of rehydrated leaf (scale = 1.0 mm) (*R. Davis & M. Henson* RD 11471b). Images: A – S. Dillon at Herbert Lukin Ridge; B, E, F – A. Markey; C – R. Davis at Doolgunna Station; D – K. Thiele.

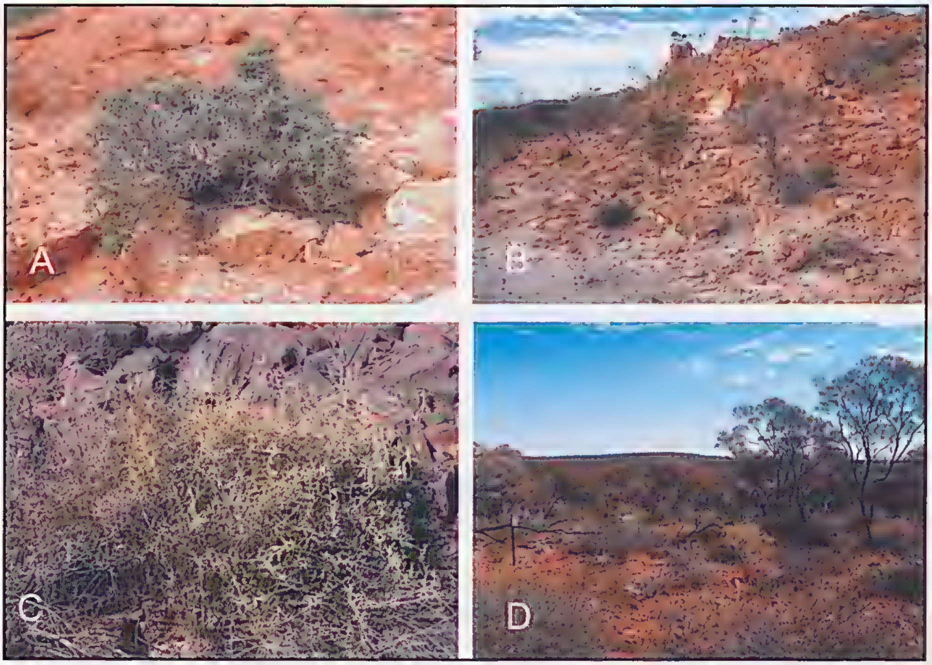


Figure 3. *Sida picklesiana*. A – example of growth habit of plants at a population near Mt Keith; B – typical habitat occupied by populations near Mt Keith; C – typical growth habit of plants at Herbert Lukin Ridge (*A. Markey & S. Dillon* 4126); D – an example of the habitat occupied at Herbert Lukin Ridge. Heavy browsing by macropods at sites near Mt Keith has produced shorter (≤ 0.5 m, densely divaricate shrubs (A, B) relative to unbrowsed shrubs along the Herbert Lukin Ridge (C, D). Photographs by G. Cockerton (A, B) and S. Dillon (C, D).

Distribution. *Sida picklesiana* is found in the Murchison and Gascoyne IBRA regions (Department of the Environment and Water Resources 2008), in an area near the townships of Wiluna, Meekatharra and Leinster (Figure 4). Most records come from locations near Wiluna, Mt Keith and Doolgunna Station. It appears to have a limited distribution, as surveys of BIF ranges in the surrounding Murchison region (Gibson *et al.* 2007; Markey & Dillon 2010; Meissner *et al.* 2009a, 2009b) and nearby calcretes (R. Meissner[1], pers. comm.) have failed to locate it in the wider region.

Ecology. *Sida picklesiana* has been recorded from open *Acacia* (*A. aneura, A. quadrimarginea, A. pruinocarpa, A. balsamea*) woodlands and shrublands on a variety of substrates, often on exposed, rocky habitats on hills of BIF and granite breakways, on footslopes of BIF hills, on stony plains (ironstone and quartz) and near creeklines. Soil types include deeper sandy clays on plains and hardpan and shallow or skeletal sandy clay loams overlying rock. Plants have been observed growing in rock crevices when on outcrops. This species appears to tolerate grazing, although plants become densely divaricate and stunted if this occurs.

Phenology. Fruiting material has been collected in April, flowering material has been collected in April, August and September, and flowering recorded in February (F. Sugg[2], pers. comm.). Flowering and fruiting appears to be rainfall-dependent as surveys during prolonged dry periods have not located reproductive material.

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[1] Rachel Meissner, Research Scientist, Science Division, Department of Environment and Conservation, Western Australia.
[2] Feigh Sugg, Project Environmental Scientist, Keith Lindbeck and Associates, Bullcreek, Western Australia.

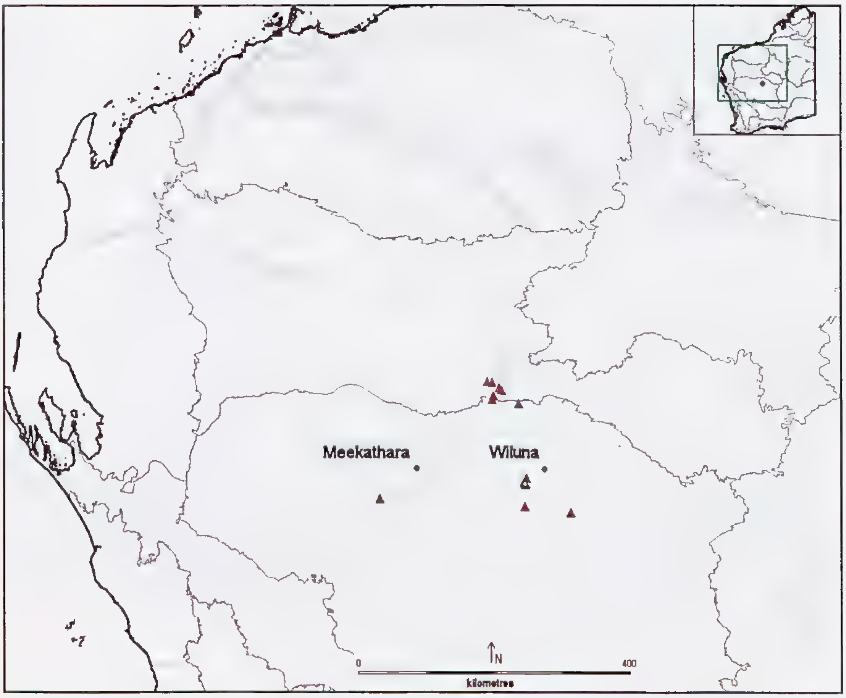

Figure 4: Distribution of *Sida picklesiana* in Western Australia (inset) and relative to nearest major townships, based on specimen data from the Western Australian Herbarium. *Version 6.1 IBRA regions* (Department of the Environment, Water, Heritage and the Arts 2008) indicated in grey.

Gender expression. From both field observations (this study, R. Davis[3], pers. comm.) and an examination of all available herbarium specimens, all have been found to have unisexual flowers and populations have been found to be usually dioecious. On a single collection (*R. Davis & M. Henson* RD 11471b), fruits that had developed from female flowers were found on a plant with male flowers. This suggests that male flowers on this plant may have been preceded by female flowers. Further field investigations are required to document the expression of floral gender in this species and determine how frequently it is monoecious.

Conservation status. Recently listed as Priority Three under the DEC Conservation Codes for Western Australian Flora, under the phrase name *Sida* sp. Wiluna (A. Markey & S. Dillon 4126).

Etymology. Named in honour of David Pickles, a Department of Environment and Conservation Environmental Officer based in Kalgoorlie, who has been an advocate for this species and steadfastly pushed for further inquiry on its distribution, taxonomy and conservation status.

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[3] Robert Davis, Technical Officer, Western Australian Herbarium, Department of Environment and Conservation, Western Australia

Generic placement

Sida picklesiana belongs within *Sida s. lat.*, along with other Australian species in an unresolved collection of species which lack the characters that define *Sida* section *Sida*, namely the calyx ten-ribbed at the base and a shoulder separating an upper dehiscent and lower indehiscent portion of the fruit (Barker 1998, 2007; Fryxell 1987). The generic limitations of *Sida* and the tribe Malveae are currently under investigation (Fryxell 1985, 1987; Holland & Reynolds 1988; Barker 1998, 2007; Fuertes *et al.* (2003). *Sida sens. lat.* may be split into separate genera in the future as a result of these investigations

Distinguishing features

Sida picklesiana is characterised by the combination of a densely branched, rounded habit with small, subsessile flowers and fruits and distinctly discolorous leaves. Unlike those of most other *Sida* species in the region, the pedicels do not appear to lengthen appreciably in fruit. Relative to the abaxial leaf surface and leaf margins, the adaxial leaf surface is less hairy, with stellate hairs with shorter, appressed rays (Figure 2F). Leaves are truncate or emarginate, ovate or oblong to narrowly ovate–oblong or depressed obovate and entire. Laminas tend to become folded on herbarium specimens, but leaves are held partially or fully open in the field unless plants are drought-stressed.

Most *Sida* species have bisexual flowers, but in a few species these have become functionally unisexual with either the styles or anthers failing to develop fully (Barker 2007). The small flowers of *S. picklesiana* are functionally unisexual, and plants are usually dioecious. Female flowers have fertile styles growing up through and protruding beyond the staminal column while the anthers are much reduced in size, borne on short filaments and do not produce pollen (Figure 2A–C). The calyx does not expand nor become chartaceous during development of the schizocarp (Figure 2D), and the mericarps are small and unornamented. Male flowers have fertile anthers on longer filaments on the apex of the staminal column and no style arms emerging from the top of the staminal column (styles are greatly reduced in size and undeveloped). In one case, fruits have been observed on a plant with otherwise male flowers (*R. Davis & M. Henson* RD 11471b), and the remnant floral parts attached to the fruit had staminodes present, verifying that it had been produced from a female rather than a bisexual flower. Male flowers have apparently well-developed ovules within an ovary of comparable size to that in female flowers. The fertility of these ovules is unknown, but the undeveloped styles would prevent self pollination in male flowers.

Variation within the new species

Leaves in the Mt Keith population are in the lower range of lengths recorded for this species (6–12 mm) and can be very small (≤ 5 mm long), and the shrubs are distinctly more divaricately branched than northern populations (Figure 3). Otherwise leaf morphological characters such as indumentum and shape match those of other populations of *S. picklesiana*. These Mt Keith populations occur on Archaean granite breakaways, and grazing pressure from local populations of euro (*Macropus robustus erubescens*) and/or black-footed rock-wallaby (*Petrogale lateralis*) is evident (Figure 3). Despite this, fruit and floral characters match those of other populations of *S. picklesiana*, and leaf size alone is insufficient evidence to segregate this as a distinct taxon. Populations from Mt Keith were found to be more likely to develop irregular fruits due to lack of fertilization of some of the ovules. Irregular development of fruits is a feature commonly associated with unisexual flowers (e.g. in *S. ectogama*, Barker 2007), but was not observed in northern populations of *S. picklesiana*. The fertilization of all mericarps suggests relatively good pollen transfer occurred within northern populations during the 2010 fruiting season.

Affinities

Sida picklesiana has clear affinities to *Sida* sp. Petermann Ranges (B.G. Thomson 2340), which is an informally named species from arid regions of Western Australia and the Northern Territory (Barker 2007) and which is currently being described by R.M. Barker and W. R. Barker (State Herbarium of South Australia, Department of Environment and Natural Resources). Both species possess small, mostly unisexual flowers and schizocarps of similar morphology. *Sida* sp. Petermann Ranges (B.G. Thomson 2340) is a variable species, and specimens from the Petermann Ranges have distinctly ovate, concolorous leaves, a glabrous staminal column, up to 5 flowers per axil, a calyx exceeding the fruit, distinct pedicels (2–8 mm in length) and are low, spreading woody shrubs (Barker 2007). Collections from the Pilbara (*K. Newbey* 10692, *S. van Leeuwen* 4377, *A.A. Mitchell* PRP1058) have markedly discolorous leaves reminiscent of *S. picklesiana*, but have longer pedicels (5–20 mm), a more lax, spindly habit and a sparse indumentum of stellate hairs on the staminal column.

Distinction of *Sida picklesiana* from similar species

The distribution of *Sida picklesiana* falls within that of other superficially similar species that are widespread through the Midwest region of Western Australia. It could be most easily confused with *S. ectogama*, *S. calyxhymenia* and *S. petrophila,* as all taxa have obovate to elliptic leaves, 5–7(8) mericarps, and a shrubby habit. These three species differ from *S. picklesiana* by their obviously pedicellate rather than subsessile flowers and calyx lobes which considerably exceed the fruit. The leaves of these three species have crenulate-serrulate margins, whereas leaf margins are entire in *S. picklesiana*. The leaf apices of *S. picklesiana* are more distinctly truncate and/or emarginate than in *S. ectogama*, *S. calyxhymenia* and *S. petrophila*. *Sida calyxhymenia* and *S. petrophila* can be distinguished from *S. picklesiana* by their bisexual flowers, concolorous leaves and an indumentum flecked with dark green stellate hairs (particularly on the calyx). *Sida ectogama* has unisexual flowers and discolorous leaves like *S. picklesiana*, but differs by its larger flowers (10–15 mm), notably ciliate and emarginate corolla lobes, a very short staminal column in male flowers, and distinctly elongate and exserted styles and stamens (Barker 2007). *Sida* sp. dark green fruit (S. van Leeuwen 2260) is a low, often sprawling and spreading shrub with narrowly oblong, discolorous leaves. It can easily be distinguished from *S. picklesiana* by its larger leaves, long-pedicellate (5–20 mm) rather than subsessile flowers and fruits, bisexual rather than unisexual flowers and 7–8(–10) rather than 5(6) styles and mericarps.

The *Sida* species key by Barker (2007) should be altered to read (from couplets 39 and 60):

39. Calyx inflated in fruit; flowers unisexual and stamens and styles well exserted from corolla; fruits with mericarps often developing unequally and remaining attached to each other for dispersal [spindly shrubs always growing under other vegetation; predominantly found in Murchison] .... **S. ectogama**

39: Calyx not inflated in fruit; flowers mostly bisexual but if unisexual stamens and styles just exserted from corolla; fruits with mericarps developing equally and detaching from each other for dispersal **39A**

39A. Flowers unisexual **39B**

39A: Flowers bisexual **40**

39B. Flowers pedicellate, in terminal leafless panicles. Tall spindly shrubs [watersheds of the Pilbara, Gascoyne and Great Sandy Desert; there are at least two taxa].. **S.** sp. **spiciform panicles (E.Leyland s.n. 14/8/90)** *p.p.*

39B: Flowers subsessile, solitary in axils. Compact, densely branched shrubs [on exposed, rocky habitats, stony plains and near creeklines in the Cue, Wiluna, Meekatharra area] .... **S. picklesiana**

60. Flowers cymose or racemose [fruits smooth or somewhat corrugated, 3.5–6.5 mm diameter, deeply grooved between mericarps; mericarps 7 or 8, ± entire at apex; widespread and variable across Australia, undoubtedly containing a number of entities] .... **S. fibulifera**

60: Flowers solitary or paired.. **61**

61. Herbs, often prostrate, sprawling, not markedly woody; flowers bisexual; calyx enclosing fruit base and sides, not exceeding it **62**

61: Spreading woody shrub; flowers unisexual; calyx exceeding the fruit; corolla similar length to calyx; flowers usually unisexual **63**

62. Stipules lanceolate, 0.3–1.4 mm wide, buds 5–angled; leaves deeply crenate [some specimens from Cape Range and Dirk Hartog Island have been referred here in the past, but is likely that true *S. corrugata* does not occur in Western Australia] .... **S. corrugata**

62: Stipules filiform, to 0.2 mm wide; buds not 5–angled; leaves crenulate [Kimberley] .... **S. brachypoda** *p.p.*

63. Flowers distinctly pedicellate, pedicels 2–20 mm long, staminal column either with or lacking stellate hairs, sprawling subshrub to 20 cm high and up to 100 cm wide [Petermann Ranges only but with some outliers in the Pilbara showing a tendency to this species] .... **S.** sp. **Petermann Ranges (B.G. Thompson 2340)** *p.p*

63: Flowers subsessile, pedicels < 5 mm long, staminal column glabrous, densely branched rounded shrub to a metre or more high and wide [Gascoyne and Murchison regions].. **S. picklesiana**

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References

Barker, R.M. (1998). A revised key to *Sida* section *Sida* in Australia, including a newly introduced species and name changes for *Sida rohlenae* var. *mutica* (Benth.) Fryxell and *S. magnifica* Domin. *Journal of the Adelaide Botanic Garden* 18: 33–41.

Barker, R.M. (2007). Two newly described species and a draft key to the species of *Sida s. lat.* from Western Australia. *Nuytsia* 17: 13–30.

Department of the Environment, Water, Heritage and the Arts (2008). *Interim Biogeographic Regionalisation for Australia (IBRA), Version 6.1.* http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html [accessed November 2010]

Fryxell, P.A. (1985). *Sidus sidarum* V – The north and central American species of *Sida*. *Sida* 11(1): 62–91.

Fryxell, P.A. (1987). *Sidus sidarum* VII – The genus *Sida* (Malvaceae) in Australia. *Sida* 12(1): 13–21.

Fuertes, J., Fryxell, P.A. & Jansen, R.K. (2003). Phylogenetic relationships and classification of the *Sida* generic alliance (Malvaceae) based on nrDNA ITS evidence. *Systematic Botany* 28(2): 352–364.

Gibson, N, Coates, D.J. & Theile K.R. (2007). Taxonomic research and the conservation status of flora in the Yilgarn Banded Iron Formation ranges. *Nuytsia* 17(1): 1–12.

Holland, A.E. & Reynolds, S.T. (1988). Five new species of *Sida* L. (Malvaceae) from Australia. *Austrobaileya* 2(5): 459–468.

Meissner, R., Owen, G. & Bayliss, B. (2009). Flora and vegetation of banded iron formations of the Yilgarn Craton: Cashmere Downs Range. *Conservation Science Western Australia* 7(2): 349–361.

Meissner, R., Owen, G. & Bayliss, B. (2009). Flora and vegetation of banded iron formations of the Yilgarn Craton: Mount Forrest–Mount Richardson Range. *Conservation Science Western Australia* 7(2): 377–389.

Markey, A.S., & Dillon, S.J. (2009). Flora and vegetation of the banded iron formations of the Yilgarn Craton: Herbert Lukin Ridge (Wiluna). *Conservation Science Western Australia* 7(2): 391–412.

Markey, A.S., & Dillon, S.J. (2010). Flora and vegetation of the banded iron formations of the Yilgarn Craton: the Booylgoo Range. *Conservation Science Western Australia* 7(3): 503–529.

Wege, J.A., Shepherd, K.A. & Butcher, R. (2007). Preface. *Nuytsia* 17.

Western Australian Herbarium (1998–). *Florabase – The Western Australian Flora.* Department of Environment and Conservation, http://florabase.dec.wa.gov.au/ [accessed March 2011]

Two species of *Inocybe* (fungi) introduced into Western Australia

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Abstract

Bougher, N.L. and Matheny, P.B. Two species of *Inocybe* (fungi) introduced into Western Australia. *Nuytsia* 21(3): 139–148 (2011). This paper reports for the first time the introduction into Western Australia from the northern hemisphere of *Inocybe curvipes* P.Karst. and *Inocybe rufuloides* Bon. The fungi are associated with planted non-native ectomycorrhizal trees – *Quercus*, *Pinus*, and possibly *Salix*. Previously, *I. curvipes* was confirmed from South Australia where it has been present for at least almost a century, but it was not known from Western Australia. *Inocybe rufuloides* had not been recorded anywhere in Australia. In this paper *I. curvipes* is also reported for the first time in Papua New Guinea, in association with planted *Quercus* and *Pinus*. *Populus* and *Quercus* are confirmed as ectomycorrhizal partners of *I. curvipes* based on ITS BLASTn analysis of environmental sequences.

Introduction

Numerous ectomycorrhizal macrofungi have been introduced from the Northern Hemisphere into Western Australia with their exotic plant associates. The most recent conspicuous introduction is the long anticipated first record of *Amanita muscaria* in Western Australia, in this case associated with *Betula pendula* (Robinson 2010). Eleven species of ectomycorrhizal fungi have been recognized in association with *Pinus* in Western Australia (Dunstan *et al.*, 1998). Some species of *Inocybe* are known to occur with planted *Pinus* in other regions of the Southern Hemisphere, but to date none have been reported in Australia (Dunstan *et al.* 1998; Walbert *et al.*, 2010). This paper reports and describes two introduced north temperate species of *Inocybe* previously unrecorded in Western Australia – *Inocybe curvipes* P. Karst., and *Inocybe rufuloides* Bon. *Inocybe curvipes* has been present in Australia for at least almost a century. This is indicated by some of the specimens in a mixed collection from South Australia in 1917 (associated plants not recorded) that recently were recognized for the first time as *Inocybe curvipes* by Matheny & Bougher (2010). *Inocybe rufuloides* had not been reported anywhere in Australia.

Methods

Fresh fruit bodies collected from the field were described following colour notations of Munsell Soil Color Charts (1954), Ridgway (1912), or Kornerup and Wanscher (1967) and then air-dried for later examination. Hand sections for microscopic observations were mounted in 3% KOH and in 1% Congo Red. Microscopic characters were drawn with a Nikon drawing tube system. Spore measurements include the hilar appendix and nodules.

DNA sequences of the internal transcribed spacer regions (ITS) and the 5' end of the nuclear large subunit ribosomal RNA region (nLSU) were produced following protocols outlined in Judge *et al.* (2009) and Matheny (2005). Seven new sequences (JN035289–JN035295) have been deposited at GenBank. The new sequences were used as queries of the NCBI nucleotide sequence database using the BLASTn search algorithm.

Taxonomic description

Inocybe curvipes P.Karst., *Hedwigia* 29: 176 (1890). *Type*: Tammela, Mustiala, Myllyperä, Finland, 22 August 1890, *P.A. Karsten s.n.* (*holo*: H 6025661).

Inocybe radiata Peck, *Bull. Torrey Bot. Club* 22: 488 (1895).

Inocybe lepidocephala Speg., *Anales Mus. Nac. Buenos Aires* 6: 126 (1898).

Inocybe variabillima Speg., *An. Mus. Nac. Bs. As.* 6: 125 (1899).

Inocybe decipientoides Peck, *Bull. Torrey Bot. Club* 34: 100 (1907).

Inocybe astoriana Murrill, *Mycologia* 3: 104 (1911).

Inocybe jamaicensis Murrill, *Mycologia* 4: 82 (1912).

Inocybe ochraceoscabra Atk., *Am. J. Bot.* 5: 214 (1918).

Inocybe globocystis Velen., *Ceské Houby*: 368 (1920).

Inocybe languinella (J.Schröt.) Konrad & Maubl., *Icon. Select. Fung.* 6: 137 (1937) *sensu auct. div.*, *non* Konrad & Maubl.

Astrosporina decipientoides (Peck) Pearson, *Trans. Brit. Mycol. Soc.* 22: 28 (1938).

Inocybe cinerascentipes Huijsman, *Fungus* 25: 26 (1955).

Inocybe sericeopoda Furrer–Ziogas, *Beih. Sydowia* 10: 62 (1995).

Inocybe curvipes var. *globocystis* (Velen.) Bon, *Docs. Mycol.* 28 (109–110): 10 (1998).

[*Inocybe cicactricata auct. non* Ellis & Everh.: R.Heim, *Encylop. Mycol.*, 1 Le Genre *Inocybe* (Paris) 1: 351 (1931)].

[*Inocybe carpta auct. non* (Scop.:Fr.) P.Kumm.: Ricken, *Die Blätterpilze*: 101 (1915)].

[*Inocybe lanuginella auct. non* (J.Schröt.) Konrad & Maubl.: W.A.Dunstan, B.Dell & N. Malajczuk, *Mycorrhiza* 8: 73 (1998)].

Pileus to 27 mm diam., conical, hemispherical, or obtusely conical in youth, becoming subcampanulate, obtusely conical or more or less convex upon expansion, margin incurved when young, later decurved; velipellis absent, surface dry, appressed fibrillose with an unbroken center when young, later finely appressed scaly on and around the center and fibrillose towards the margin; margin torn and at times radially rimulose; dark brown (10YR 3/3) throughout or brown (10YR 4/3) or shading brown towards the margin, at times the edge of the margin is yellowish brown (10YR 5/4) – 'Mummy Brown' to 'Bister'to 'Snuff Brown', shading to 'Snuff Brown', 'Saccardo's Umber' to 'Tawny-Olive' towards the margin; context pallid or white, not changing color where bruised. *Lamellae* adnate to adnexed, moderately close, 34–48 L with several tiers of lamellulae, ventricose in age, up to 4 mm broad; light gray when immature to light yellowish brown or brown, eventually dark yellowish brown in age; edges pallid and fimbriate. *Stipe* 20–40 mm × 3–7 mm at apex, even or with a slightly swollen base; cortina fugacious, surface nowhere pruinose, finely–fibrillose to fibrillose or twisted fibrillose, generally pallid above shading to light brown or 'Avellaneous' below, but brown to dark brown or 'Bister' at the base and upwards in age; context solid, mostly pallid, at times with subtle pinkish brown cortex. Odour spermatic when first cut, later mixed with an acidulous component. Taste not recorded. Spore deposit not recorded.

Basidiospores (8.5) 9–12 × 5–6.5 µm, mean 10.3 × 5.6 µm, mean profile 10.3 × 5.6 µm (n= 30), mean face view 9.9 × 5.7 µm (n= 30), mean L/B ratio profile 1.82, mean L/B ratio face view 1.75, gibbous about a trapeziform outline with 6–10 moderate to small-sized nodules to 2 µm tall, at times these merely corners, usually with a distinct apical nodule, yellowish brown, apiculus distinct. *Basidia* 26–34 × 8–11 µm, predominantly quadrisporic, but also sometimes bisporic and monosporic then with long sterigmata to 15 µm, clavate, cylindric or ventricose (particularly when mono- and bi-sporic). *Lamellae trama* of parallel hyphae –12 µm wide, with similar but narrower hyphae in the subhymenium. *Pleurocystidia* 47–73 × 19–27 µm, broadly fusiform or saccate and noticeably tapered towards the apex, this usually acute (not obtuse or well-rounded) and crystalliferous, with a slender, long basal pedicel (e.g. 12 × 5µm) ; thick-walled, walls to 2.5 µm thick, hyaline. *Cheilocystidia* 48–66 × 15–24 µm similar to pleurocystidia but more variable in shape with abundant small clavate and vesiculose paracystidia among the larger cystidia. *Stipitipellis* with no caulocystidia; sparse vesture hyphae observed on lower part of the stipe. *Pileipellis* a cutis of cylindric hyphae 4–15 µm wide, many with brown encrusting pigment, some emerging in scattered bundles and with cystidioid terminal elements e.g. lageniform 51 × 4 µm. *Clamp connections* present in all tissues. (Figures 1, 2)

Specimens examined. WESTERN AUSTRALIA: Carine, Perth, gregarious on soil under *Quercus* in suburban backyard garden, 31 Aug. 2001, *B. Dunstan PBM* 2210 (PERTH 007676859, formerly CSIRO E7058); Botany Department, campus of University of Western Australia, Crawley, Perth, in rose garden, 6 June 1973, *D. Waldie s.n.* (PERTH 00763578). AUSTRALIAN CAPITAL TERRITORY: Black Mountain CSIRO, Canberra, in grass at base of *Pinus radiata* near the herbarium, 14 Feb. 1990, *E. Cooper EC* 4 (CANB 404918, ITS and LSU sequences respectively: JN035289, JN035293). SOUTH AUSTRALIA: Belair National Park, unrecorded habitat and plant association, 12 May 1917, *J. B. Cleland s.n.* (AD12143). VICTORIA: Templestowe, Melbourne, growing in lawn in rings under weeping willow (presumably *Salix*), 29 May 1963, *P. Jenkins s.n.* (MEL 1054882). PAPUA NEW GUINEA: near Massy, along road under *Pinus*, 27 July 2003, *R. Treu* TR37–03 (M–0138268, ITS and LSU sequences respectively: JN035290 and JN035294). JAMAICA: Cinchona, wet mountains area, 4500–5200 ft elev, in a clay road, collected between 25 Dec. 1908 and 8 Jan. 1909, *W.A. Murrill & E.L. Murrill* WAM & ELM 595 (WTU, isotype of *Inocybe jamaicensis* Murrill). UNITED STATES OF AMERICA: Massachusetts, in open grassy ground, Aug. and Sep., *W.D. Jackson (*WTU, isotype of *Inocybe radiata* Peck); Washington, next to Burke–Gilman Trail near the Wall of Death, University District, Seattle, on disturbed soil along side of road near *Corylus*, *Prunus*, and *Populus*, 18 June 1998, *P.B. Matheny* PBM1007 (WTU); on grassy lawn under introduced *Arbutus unedo* with *Pinus* in the vicinity, 28 Oct. 1998, *P.B. Matheny* PBM 1328 (WTU); Green Lake, Seattle, King County, on ground under *Betula,* 15 Sep. 2002, *J.F. Ammirati & M.T. Seidl* PBM 2401 (WTU).

Distribution and habitat. On soil under introduced *Quercus* or *Pinus radiata*, and possibly *Salix*, introduced into Western Australia, Australian Capital Territory, South Australia, Victoria, and Papua New Guinea. Fruiting February, May to August (in Australia).

Notes. Inocybe curvipes is distinctive microscopically by its broadly fusiform hymenial cystidia that are tapered at the acute apex (Figures 2C, 2D), and its long spores with 6–10 moderate to small-sized nodules or merely corners (Figure 2A). The presence of monosporic and bisporic basidia (Figure 2B) is not a consistent feature of this species but they are present in some collections from Australia and elsewhere. They occur in only one of the two Western Australian collections examined (PERTH 07676859). *Inocybe curvipes* has a restricted habitat in Australia as it occurs in gardens and suburban plantings of *Quercus* or *Pinus* or possibly *Salix*. It has not been found in natural vegetation or in exotic plantations of *Pinus* in Australia. We previously recognized this species for the first time in Australia – from South Australia (Matheny & Bougher 2010), but it had not been reported in other parts of Australia or in Papua New Guinea.

BLASTn results of our *I. curvipes* ITS sequences reveal 16 matches (97–99% similarity) with unidentified environmental sequences from ectomycorrhizas of *Populus* in plantations (Stefani *et al.* 2009), two matches (99% similarity) with *Quercus* ectomycorrhizas from a nursery setting (Leski *et al.* 2010), two Swedish isolates labeled *I. curvipes* (99% similarity), and one Estonian isolate labeled *I. cf. rennyi* (99% similarity) (Ryberg *et al.* 2008). These data unequivocally confirm *I. curvipes* as an ectomycorrhizal associate of *Populus* and *Quercus* in plantation and nursery settings outside Australia. The high similarity with the isolate labeled *I.* cf. *rennyi* is noteworthy because presumably the collection from which the sequence was obtained must feature the unusually elongated spores typical of *I. rennyi* (Kropp & Matheny 2004). Evidence is mounting that either *I. rennyi* represents a polyphyletic taxon, or is at least merely an aberrant spored version of *I. curvipes*. ITS sequences of collections from the ACT and Papua New Guinea differ at three sites, two of which are polymorphic in the ACT collection.

Inocybe curvipes has been present in Australia for at least almost a century. A collection of it from South Australia (AD12143) was made by J. B. Cleland in 1917. That collection was originally unidentified by Cleland, and later incorporated together with *Asterosporina asterospora* sensu Cleland and merged into the protologue of *Inocybe dewrangia* Grgur. (Grgurinovic 1997, Matheny & Bougher 2010). *Inocybe curvipes* was likely introduced into Australia and Papua New Guinea together with imported north temperate ectomycorrhizal plants such as *Quercus* and *Pinus* species. It has been similarly introduced into other southern hemisphere regions, e.g. *I. curvipes* (as *I. lanuginella*) is recorded as an ectomycorrhizal fungus associated with *Pinus* in South Africa (Dunstan *et al.*, 1998). It is also widespread in South America under *Pinus* (Cortez & Coelho 2005).

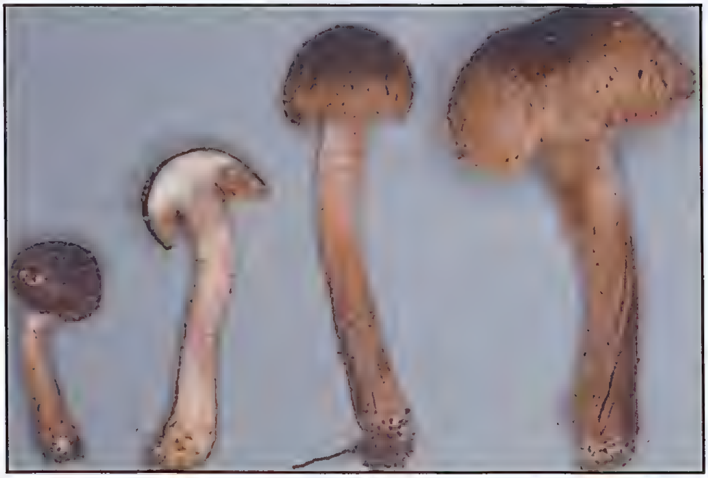

Figure 1. Basidiomes of *Inocybe curvipes* (PERTH 007676859).

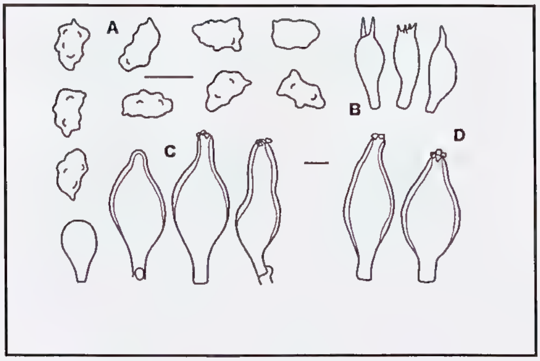

Figure 2. Micromorphology of *Inocybe curvipes* (PERTH 007676859). A – spores; B – basidia; C – cheilocystidia; D – pleurocystidia. Scale bars = 10 µm (longer bar for spores only).

Inocybe curvipes is a toxic species that can be expected to occur in urban or suburban habitats of non–native, north temperate ectomycorrhizal trees. While revising collections of *Inocybe* at MEL in Melbourne, we identified one from the 1960s as *I. curvipes* (originally identified as *Inocybe* sp. – MEL1054882), which was annotated with the words "cause of muscarin poisoning in woman who gathered it to eat it in mistake for mushroom".

Inocybe curvipes is widespread in the northern hemisphere temperate zone having been described numerous times in Europe, eastern and western North America, and Central America. As is the case with many other Inocybaceae, *I. curvipes* has been misidentified numerous times since it was originally published in 1890 by Karsten; for example, two eminent American mycologists, C. H. Peck and W. A. Murrill, both subsequently published this species under two different newly proposed names (see synonymy above). Kauffman (1924) reported *I. ochraceoscabrosa* Atk. as a synonym of *I. decipentoides*, both of which are later synonyms of *I. curvipes* (Stangl 1989). Our list of synonyms follows Stangl (1989), to which we add the following: *I. radiata* Peck and *I. jamaicensis* Murrill based on studies of the types. Stangl's list of synonyms of *I. curvipes* follows much of Singer (1949), who reported the following species as synonyms of *I. decipientoides*: *I. astoriana* Murrill, *I. ochraceoscabrosa* Atk., *I. globocystis* Velen. as reconfirmed by Kuyper (1985), *I. carpta* (Scop.: Fr.) Sacc sensu Ricken, and later in the same publication *I. variabillima* Speg. We also list *I. sericeopoda* Furrer–Ziogas as a synonym of *I. curvipes* based on the figures depicted in Furrer–Ziogas (1995) and in line with the synonymy presented in Esteve–Raventós & Caballero (2009); however, we have not examined the type, which is indicated in a private herbarium.

Inocybe cicatricata sensu R. Heim (1931; Fig. 202) is *I. curvipes*, no doubt, given the morphology of the cystidia depicted in Heim's drawings. Stuntz (1947) separated *I. cicatricata* from *I. decipientoides* and his line drawings bear out their separation; however, Stuntz states that his material of *I. cicatricata* '... agrees quite well with Heim's description of *Inocybe cicatricata* Ellis & Ev.' *Inocybe cicatricata* sensu Stuntz (1947), however, in our opinion is not *I. curvipes*.

Inocybe rufuloides Bon, *Docums. Mycol.* 14 (53): 28 (1984). *Type*: Cayeux-sur-Mer (Somme), France, 19 May 1983, *Bon, Vast & Claus s.n.* (*holo*: MB 83038).

Pileus 5–35 mm diam.; convex to hemispherical in button, then conico-campanulate, maintaining a broad central umbo and not or very reluctantly expanding to applanate in old age; margin plane at first with evanescent whitish appendiculate (suggestive of a partial veil); surface dry radially fibrillose with appressed pale silvery appressed fibrils some fusing into narrow appressed squamules, centre of pileus more matted-fibrillose, overlying the mousey brown (near 6E4) to dull bronze-brown (near 6E5) then later darker brown (near 7F8) pileal surface; context dull cream, paler in cap, up to 5 mm thick above stipe apex. Partial veil: sparse, rapidly evanescent whitish fibrils. *Lamellae* broadly adnexed, slightly ventricose, to 7 mm deep, crowded then closely spaced with abundant lamellulae in three tiers; edge minutely cystidiate (but not conspicuous to the eye), edge paler or concolorous with face, pale cream in button, then pale fawn (near 5B4), finally dull brown (near 5D6–6D6) or dull greyish brown (near 6D4) never dark or rusty brown. *Stipe* to 50 × 8 mm; cylindric with base slightly swollen or clavate; solid; surface longitudinally silky-fibrillose with whitish appressed fibrils over entire length (easy to remove on handling), fibrils breaking up into minute floccules near apex, but no pruinosity present; dull whitish with slight pinkish tinge especially towards the apex in some specimens, darker and dull when old. *Basal mycelium* white but not copious or conspicuous. *Odour* grassy, spermatic. *Taste* not recorded. Spore deposit dark brown (near 6F5–6F6 to 7F6).

Basidiospores 11–12.5 (13) × 5.5–6.5 µm, mean 11.3 × 6.1 µm, mean profile 11.3 × 6.1 µm (n= 30), mean face view 11.4 × 6.1 µm (n= 30), mean L/B ratio profile 1.85, mean L/B ratio face view 1.87, smooth, ellipsoid to ovoid in face view, ovoid to subamygdaliform in profile sometimes with slight adaxial depression, with slightly thick wall, yellowish brown, apiculus small but prominent. *Basidia* 25–37 × 8.5–11.5 µm, quadrisporic, clavate to narrowly ventricose, hyaline. *Lamellae trama* of parallel clamped hyphae to 16 µm wide, subhyenium of narrower hyphae 2–4 µm wide. *Pleurocystidia* 53–75 × 14–17 µm, lageniform, subfusiform or utriform, crystalliferous; thick-walled, walls to 2 µm thick, hyaline. *Cheilocystidia* 20–56 × 11–15.5 µm, similar to pleurocystidia, crowded forming sterile lamella edge, thin-walled paracystidia sometimes in short chains. *Stipitipellis* with few caulocystidia similar to the hymenial cystidia at the stipe apex, end cells otherwise undifferentiated. *Pileipellis* a cutis of cylindric hyphae to 10 µm wide, many with brown encrusting pigment, subpellis not well differentiated but with more tightly packed hyphae. *Clamp connections* present in all tissues. (Figures 3, 4)

Specimens examined. WESTERN AUSTRALIA: Modong Nature Reserve, Jandakot Regional Park, Thomas Rd, Oakford, Perth, in gregarious troops in disturbed gravelly roadside edge near *Pinus* plantation with *Melaleuca preissiana* and *Adenanthos* sp. also present, 9 July 2006, *N. Bougher, N. Goldsborough & J. Keeble* E8353 (PERTH 07700598 (ITS and LSU sequences respectively: JN035292, JN035295); Bold Park, Perth, abundant in litter under *Pinus radiata* trees, adjacent to Ecology Centre, just South of Oceanic Drive, 10 July 2008, *N. Bougher* 00479 (PERTH 08073147); Bold Park, Perth, same location, 1 June 2010, *N. Bougher* 00618 (PERTH 08305978)(ITS sequence: JN035291); Bold Park, Perth, abundant along edge of limestone track in banksia woodland with *Pinus radiata* plantation nearby (30 m to nearest pine tree), Bold Park's central pine plantation, 29 July 2009, *N. Bougher* 00541 (PERTH 08305951).

Distribution and habitat. On soil, often in abundance, under planted *Pinus radiata*, introduced to Western Australia. Fruiting June to July.

Notes. Inocybe rufuloides can be recognized in Western Australia by its occurrence in pine plantations together with a combination of features including its dull bronze-brown, radially fibrillose pileus with some whitish overhanging fibrils when young, pale lamellae, pinkish upper stipe, and grassy/spermatic odour (Figure 3). It has smooth, ellipsoid to subamygdaliform spores, and metuloid cheilocystidia and pleurocystidia (Figure 4). *Inocybe rufuloides* is an ectomycorrhizal associate of *Pinus* species in Europe, e.g. *Pinus pinea* (Iotti *et al.* 2005). Collections of *I. rufuloides* from France listed by Bon (1984) in his original description indicate a possible association with *Pinus* and other plants such as *Picea*. In Western Australia *I. rufuloides* is an exotic species apparently exclusively associated with *Pinus*, and it is not yet known to associate there with other plants.

We identify the Western Australian collections cited above as *Inocybe rufuloides* in view of their conformity with the range of attributes presented in the literature for that species, and sequence similarity with material identified by J. Vauras as *I. rufuloides* (Ryberg 2009). Vesper and Richter (2010) present a comparison of their morphological data for *I. rufuloides* against data published by eight other authors. The Western Australian material conforms within the range of attributes presented, but the attributes presented show considerable variation. For example, caulocystidia are variably considered absent or present by the authors listed by Vesper and Richter (2010). The Western Australian collections have very few differentiated terminal cells on the stipe surface, with only some cauloparacystidia (broad shape, not or barely thick–walled) and rare metuloid caulocystidia (we observed only one metuloid in samples from 3 fruit bodies in each of 3 different collections). Further evidence pointing to morphological variability in *I. rufluoides* is that the Western Australian collections are much less reddish–brown overall than for specimens shown in the image of *I.* aff. *rufuloides* by Vesper and Richter (2010).

Iotti *et al.* (2005) reported that *I. rufuloides* is one of two *Inocybe* species found contaminating *Tuber* infected plants in experimental truffières in Italy. However, the identity of their material is called into question given that a BLASTn search of DQ067579 (sequence generated from a sporocarp) shows it to be highly similar (98% similarity) to *I. pseudodestricta* Stangl & J. Veselský, FN550908, based on material identified by J. Vauras. BLASTn searches of Western Australian *I. rufuloides* match a sequence produced by Ryberg (2009), using material from Italy identified by J. Vauras as *I. rufuloides*.

The gross morphology of *Inocybe pseudostricta* as described by Stangl and Veselský (1973) is indeed similar to that of the Western Australian collections, including having a pale brownish stipe that is reddish along the upper third. However, the protologue for *I. pseudodestricta* by Stangl and Veselský (1973) shows at least two significant microscopical attributes that differ from the Western Australian collections: (1) more strongly amygdaliform spores lacking the adaxial flattening or depression present on the spores of Western Australian collections; (2) presence of long, narrow caulocystidia.

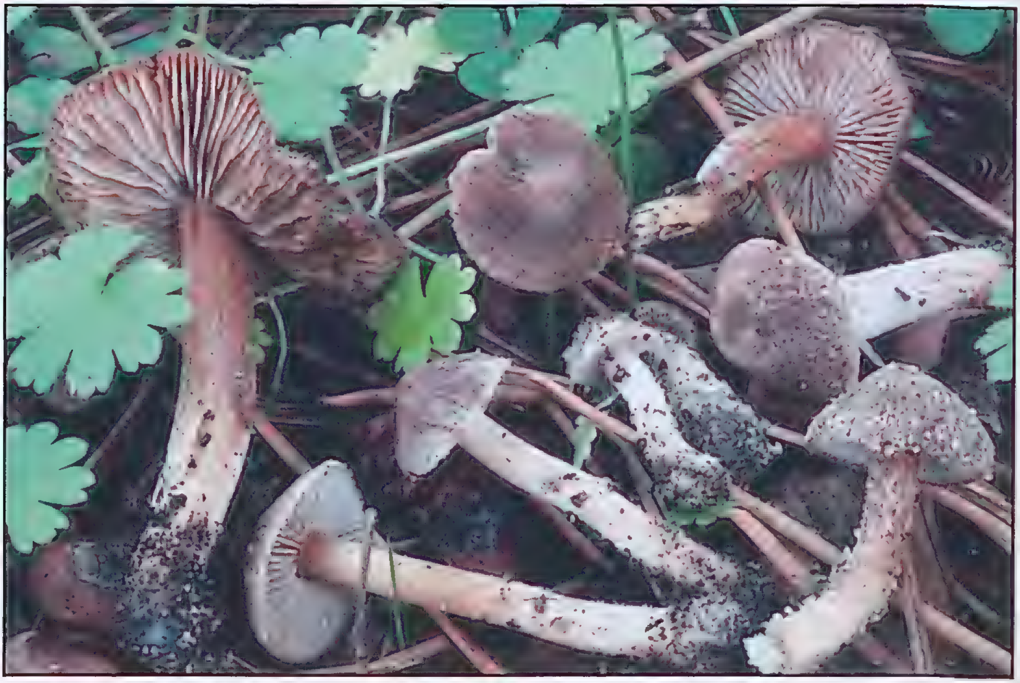

Figure 3. Basidiomes of *Inocybe rufuloides* (PERTH 08073147).

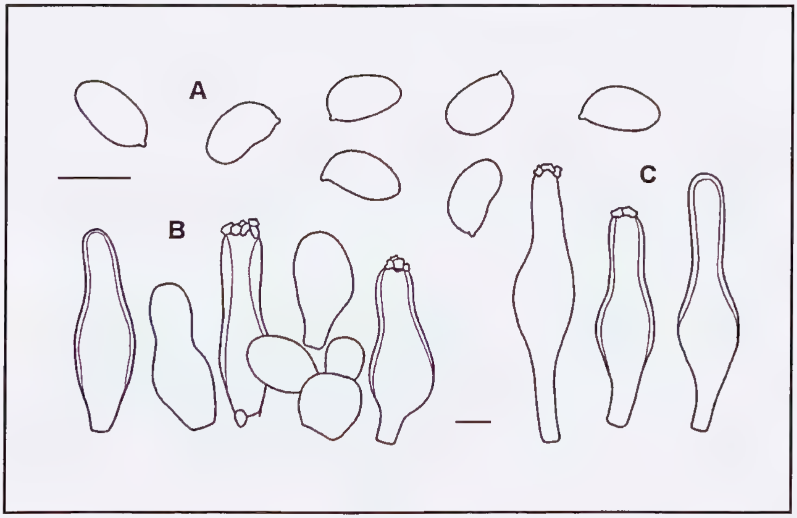

Figure 4. Micromorphology of *Inocybe rufuloides* (PERTH 08073147). A – spores; B – cheilocystidia; C – pleurocystidia. Scale bars = 10 μm (longer bar for spores only).

Acknowledgements

Our thanks to Dr. Pertti Salo at the Finnish Museum of Natural History for providing us with collection data for the type of *Inocybe curvipes*. We thank Dr. Tom May at the National Herbarium of Victoria for retrieving the collection data and annotations for MEL1054882. We also appreciate herbarium loans from Roland Treu and staff at the Botanische Staatssammlung München (M) and the Australian National Herbarium, Canberra (CANB). Examination of type materials was done at the University of Washington Herbarium (WTU). Both authors acknowledge financial support from the Office of Research and the College of Arts & Sciences at the University of Tennessee, and a research grant from the U.S. National Science Foundation (DEB–0949517). Also we acknowledge a research grant from the Australian Government's Australian Biological Resources Study National Taxonomy Research Grant Program (RFL211–31), and financial support from the Western Australian Naturalists' Club Inc.

References

Bon, M. (1984). Macromycetes de la zone maritime picarde. Les Inocybes sabulicoles. *Documents Mycologiques* 14: 9–40.

Cortez, V.G. & Coelho, G. (2005). Additions to the mycobiota (Agaricales, Basidiomycetes) of Rio Grande do Sul, Brazil. *Iheringia Série Botanica* 60: 69–75.

Dunstan, W.A., Dell, B. & Malajczuk, N. (1998). The diversity of ectomycorrhizal fungi associated with introduced *Pinus* spp. in the southern hemisphere, with particular reference to Western Australia. *Mycorrhiza* 8: 71–79.

Esteve–Raventós, F. & Caballero, A.M. (2009). Especies nuevas e interesantes del género Inocybe (1). *Fungi non delineati* 47: 1–128.

Furrer–Ziogas, C. (1995). *Inocybe sericeopoda sp. n. Beihefte Sydowia* 10: 62–66.

Grgurinovic, C.A. (1997). *Larger fungi of South Australia.* (Botanic Gardens of Adelaide and State Herbarium: Adelaide.)

Heim, R. (1931). Le Genre *Inocybe. Encylopédie Mycologique I*: 1–429.

Judge, B.S., Ammirati, J.F., Lincoff, G.H., Trestrail, J.H. & Matheny, P.B. (2009) Ingestion of a newly described North American mushroom species from Michigan resulting in chronic renal failure: *Cortinarius orellanosus. Clinical Toxicology* 48: 545–549.

Iotti, M., Marchetti, M., Bonuso, E. & Zambonelli, A. (2005). Morphological and molecular characterization of the mycorrhizas of *Inocybe rufuloides* and *I. splendens. Mycotaxon* 94: 75–84.

Kauffman, C.H. (1924). *Inocybe. In: North America flora.* Vol. 10, pt. 4, p. 227–260 (New York Botanical Garden: New York.)

Kornerup, A. & Wanscher, J.H. (1967) *Methuen handbook of colour.* 2nd edn. (Methuen:London).

Kropp, B.R. & Matheny, P.B. (2004). Basidiospore homoplasy and variation in the *Inocybe chelanensis* group in North America. *Mycologia* 96: 295–309.

Kuyper, T.W. (1985). Studies in *Inocybe*—I. Revision of the new taxa of *Inocybe* described by Velenovsky. *Persoonia* 12: 375–400.

Leski, T., Pietras, M. & Rudawska, M. (2010). Ectomycorrhizal fungal communities of pedunculate and sessile oak seedlings from bare–root forest nurseries. *Mycorrhiza* 20:179–190.

Matheny, P.B. (2005). Improving phylogenetic inference of mushrooms using RPB1 and RPB2 sequences (*Inocybe*; Agaricales). *Molecular Phylogenetics and Evolution* 35: 1–20.

Matheny, P.B., & Bougher, N.L. (2010). Type studies of *Inocybe* from Australia. *Muelleria* 28: 87–104.

Munsell Color Company (1954). Munsell soil color charts. (Munsell Color Company: Baltimore, Md.)

Ridgway, R. (1912). *Color standards and color nomenclature.* (The Author: Washington, D. C.)

Robinson, R. (2010). First record of *Amanita muscaria* in Western Australia. *Australasian Mycologist* 29: 4–6.

Ryberg, M. (2009). *An evolutionary view of the taxonomy and ecology of Inocybe (Agaricales) with new perspectives gleaned from GenBank metadata.* PhD dissertation, University of Gothenburg, Department of Plant and Environmental Sciences.

Ryberg, M., Nilsson, R.H., Kristiansson, E., Topel, M., Jacobsson, S. & Larsson, E. (2008). Mining metadata from unidentified ITS sequences in GenBank: a case study in *Inocybe* (Basidiomycota). *BMC Evolutionary Biology* 8: 50.

Singer, R. (1949). The 'Agaricales' (mushrooms) in modern taxonomy. *Lilloa* 22: 5–832.

Stangl, J. (1989). Die Gattung *Inocybe* in Bayern. *Hoppea* 46: 5–388.

Stangl, J. & Veselský, J. (1973). Zweiter beitrag zur kenntnis der selteneren *Inocybe* –Arten. Česká Mykologie 27: 11–25.

Stefani, F.O.P., Moncalvo, J.–M., Sequin, A., Berube, J.A. & Hamelin, R.C. (2009). Impact of an 8–year–old transgenic poplar plantation on the ectomycorrhizal fungal community. *Applied and Environmental Microbiology* 75: 7527–7536.

Stuntz, D.E. (1947). Studies in the genus *Inocybe*. I. New and noteworthy species from Washington. *Mycologia* 39: 21–55.

Vesper, A. & Richter, T. (2010). Studien zu zwei wenig bekannten risspilzen, *Inocybe rufuloides* und *I. subporospora*. *Boletus* 32: 100–105.

Walbert, K., Ramsfield, T.D., Ridgway, H.J. & Jones, E.E. (2010). Ectomycorrhizal species associated with *Pinus radiata* in New Zealand including novel associations determined by molecular analysis. *Mycorrhiza* 20: 209–215.

SHORT COMMUNICATIONS

Re-evaluation of some infraspecific taxa in *Ptilotus* (Amaranthaceae)

This short communication is a continuation of work evaluating infraspecific taxa in Western Australian *Ptilotus* R.Br. (Davis 2009; Davis & Butcher 2010a, 2010b) for the forthcoming *Flora of Australia* treatment of Amaranthaceae. After examining the type of *Ptilotus grandiflorus* F.Muell. var. *lepidus* (F.Muell.) Benth. (= *P. lepidus* F.Muell.) from MEL and collections of *P. grandiflorus sens. lat.* at PERTH, it is apparent that *P. grandiflorus* var. *lepidus* does not have taxonomic merit and should be synonymised under *P. grandiflorus*. Conversely, after examining the infraspecific taxa of *P. humilis* (Nees) F.Muell. it is clear that *P. humilis* var. *parviflorus* Benth. warrants the rank of species. It is here elevated as *P. parviflorus* (Benth.) R.W.Davis.

Taxonomy

Ptilotus grandiflorus F.Muell., *Fragm.* 1: 237 (1859). *Type*: Ad flumen Murchison, *A. Oldfield s.n.* (*holo*: MEL 1058701, image seen).

Ptilotus lepidus F.Muell., *Fragm.* 4: 89 (1864); *Ptilotus grandiflorus* F.Muell. var. *lepidus* (F.Muell.) Benth., *Fl. Austral.* 5: 243 (1870). *Type*: near Shark Bay, W.A., *M. Brown s.n.* (*holo*: MEL!).

Prostrate or ascending *herbs*, to 30 cm high. *Stems* ribbed, sparsely hairy to glabrous, with nodose hairs. *Basal leaves* oblanceolate, 30–80 mm long, 2–10 mm wide, sparsely hairy to glabrous, with nodose hairs. *Cauline leaves* alternate, oblanceolate, 5–40 mm long, 1–10 mm wide, sparsely hairy to glabrous, with nodose hairs. *Inflorescences* terminal, solitary or clustered, pink or white, ovoid to cylindrical, 10–35 mm long, 14–23 mm diam.; *bracts* narrowly ovate, translucent, 4.4–5.5 mm long, glabrous, apex slightly apiculate, with an obscure midrib; *bracteoles* narrowly ovate to obovate, translucent, 4.4–5.3 mm long, glabrous, apex slightly apiculate, with an obscure midrib. *Flowers* pedicellate; *outer tepals* pink to white, (5)6–10.5 mm long, puberulent except at the very base, sericeous at base, with nodose to subverticillate hairs, apices truncate to rounded, serrated; *inner tepals* with a basal tuft of hairs on inner surface; *staminal cup* 0.9–1.1 mm long; *stamens* 5; *ovary* glabrous; *style* slightly curved to straight, central to sub-centrally fixed to ovary, 1.1–1.2 mm long. *Seed* not seen.

Selected specimens. WESTERN AUSTRALIA: 250 m N of the Greenough River on W boundary of East Yuna Reserve, 15 Nov. 1997, *P.G. Armstrong s.n.* (PERTH); between Hamelin Pool and Shark Bay, Aug. 1940, *W.E. Blackall* 4582 (PERTH); 9 km N of Nerren Nerren rest area on North West Coastal Highway, 16 Oct. 2005, *G. Byrne* 1735 (PERTH); 6 km SSE of Meegea Hill, Milly Milly Station, 9 May 1995, *R.J. Cranfield* 9751 (PERTH); 56 km W of Mullewa on Yalgoo Road, 15 Oct. 1996, *B.A. Fuhrer* 96/35 (MEL, PERTH); Coolcalalaya Road, Northampton, 22.9 km NE of North West Coastal Highway, 5 Oct. 2004, *F. Hort, J. Hort & J. Shanks* 2331 (PERTH); Perenjori Hills, 13 Oct. 2005, *R. Meissner & Y. Caruso* 368 (PERTH); 16 km W of Barnong turnoff on the Mullewa to Yalgoo Road, 20 Oct. 2003, *L. Sweedman* 6198 (PERTH); Yuna Nature Reserve, 1.3 km from the west end of Campbells Road, 28 Sep. 2007, *M.E. Trudgen & M. Guest* MET 22546 (PERTH).

Distribution and habitat. Ptilotus grandiflorus occurs in near-coastal areas from Shark Bay to Geraldton, stretching inland to Kalgoorlie in the south-east of its range and to Meekatharra in the north-east. Often found in *Acacia* scrublands and open *Eucalyptus* woodlands, usually growing on red sand or sandy loams.

Notes. Although Mueller (1859, 1864) described both *Ptilotus grandiflorus* and *P. lepidus* he gave no indication of the differences between these taxa, saying only that they were somewhat similar. Bentham (1870) regarded tepal length to be the only morphological difference between *P. grandiflorus* and *P. lepidus* (4–5 lines long, *c.* 8–10 mm long, in *P. grandiflorus* and to 3 lines long, *c.* 6 mm long, in *P. lepidus*). He therefore reduced *P. lepidus* to a variety of *P. grandiflorus*.

Examination of the type of *P. lepidus* (=*P. grandiflorus* var. *lepidus*) found that tepal size has a greater measurement range than previously given by Bentham, ranging from 5.5–7.5 mm long. Based on the specimens currently held at PERTH, tepal lengths in *P. grandiflorus sens. lat.* were found to vary from 6–10.5 mm long. Given that tepal size can vary due to seasonal effects, that tepal lengths overlap between the varieties, and that there are no other discernable morphological or quantitative differences between them, it is concluded here that *P. grandiflorus* var. *lepidus* should not be recognised as a distinct taxon and it is therefore synonymised under *P. grandiflorus*.

Ptilotus parviflorus (Benth.) R.W.Davis, *stat. et comb. nov.*

Ptilotus humilis (Nees) F.Muell. var. *parviflorus* Benth., *Fl. Austral.* 5: 245 (1870). *Type*: S.W. Australia, 1860, *Mr Burges s.n.* (*holo*: K 000356830, image seen).

Ptilotus humilis (Nees) F.Muell. subsp. *parviflorus* (Benth.) Benl ms, *nom. inval.*

Prostrate *herbs*, to 6 cm high. *Stems* glabrous or sparsely hairy, with crisped nodose hairs. *Basal leaves* oblanceolate, 10–40 mm long, 1–5 mm wide, glabrous or sparsely hairy, with nodose hairs. *Cauline leaves* alternate, oblanceolate or obovate, 5–40 mm long, 1–3 mm wide, glabrous or sparsely hairy, with nodose hairs. *Inflorescences* terminal, solitary or sometimes clustered, white-green with pink tinge, ovoid to cylindrical, 5–25 mm long, 8–10 mm diam.; *bracts* ovate, translucent, 3.5–4 mm long, glabrous or hairy, attenuate at apex, with an obscure midrib; *bracteoles* ovate, translucent, 3.5–4 mm long, glabrous, attenuate at apex, with an obscure midrib. *Flowers* pedicellate; *outer tepals* white-green with pink tinge along medial section, 3.8–4.5 mm long, with sparse, silky, verticillate hairs on lower half, puberulent on the distal half, hairs simple, apices truncate to slightly rounded, serrated; *inner tepals* with a basal tuft of hairs on inner surface; *staminal cup* 0.5–0.8 mm long; *stamens* 5; *ovary* glabrous; *style* straight, centrally fixed to ovary, 0.6–0.9 mm long. *Seeds* glossy, brown, 0.7–0.9 mm long.

Selected specimens. WESTERN AUSTRALIA: Mount Manning Range, 12 Sep. 1980, *A.A. Burbidge* 203 (PERTH); SE of Coolcalalaya Station, 13 Oct. 1988, *A.H. Burbidge* 4246 (PERTH); *c.* 4.4 km SSE of North West Peak, Mount Manning Range, 3 Nov. 1995, *N. Gibson & B. Moyle* 3387 (PERTH); Drages Paddock, 4 km E of Woolgorong homestead, 17 Sep. 1996, *M. Officer* MO 138 (PERTH); Woolgorong Homestead, 29 Aug. 1995, *M. Officer* MO 98 (PERTH).

Distribution and habitat. Ptilotus parviflorus is relatively poorly collected and is only known from disjunct populations north and north-east of Geraldton, and to the far south-east at Mount Manning

Range. It grows in scrublands on sandy or sandy-clay soils. The distributions of the widespread *P. humilis* and *P. parviflorus* overlap in the Geraldton region, however, no intermediates have been observed.

Notes. Although *Ptilotus parviflorus* is superficially similar to *P. humilis*, on close inspection there are obvious and significant floral differences between them. For example, in *P. parviflorus* the tepals are 3.8–4.5 mm long with a sparse, silky indumentum of verticillate hairs, the bracteoles are ovate, the ovary and style are slender and 0.6–0.9 mm long, and the seeds are globose. By comparison, in *P. humilis* the tepals are 5–7.7 mm long with a much longer, denser, woolly indumentum of verticillate hairs, the bracteoles are orbicular, the ovary and style are stouter and 0.4–0.6 mm long, and the seeds are ovoid.

References

Bentham, G. (1870). *Flora Australiensis.* Vol. 5, p. 243. (Reeve: London.)

Davis, R.W. (2009). *Ptilotus luteolus*, a new combination in *Ptilotus* (Amaranthaceae). *Nuytsia* 19: 311–312.

Davis, R.W. & Butcher, R. (2010a). Re-evaluation of *Ptilotus polystachyus sens. lat.* (Amaranthaceae) and creation of the new combination *Ptilotus giganteus*. *Nuytsia* 20: 217–227.

Davis, R.W. & Butcher, R. (2010b). The status of infraspecific taxa and new subspecies in *Ptilotus stirlingii* (Amaranthaceae). *Nuytsia* 20: 261–270.

Mueller, F. von. (1859). *Fragmenta phytographiae Australiae.* Vol. 1, p. 237. (Auctoritate Guberni Coloniae Victoriae: Melbourne.))

Mueller, F.von (1864). *Fragmenta phytographiae Australiae.* Vol. 4, pp. 89–90. (Auctoritate Guberni Coloniae Victoriae: Melbourne.))

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Validation of the name *Drosera monticola* (Droseraceae), a species from the south-west of Western Australia.

Drosera monticola (Lowrie & N.G.Marchant) Lowrie was first described as *Drosera stolonifera* Endl. subsp. *monticola* Lowrie & N.G.Marchant in 1992 (Lowrie & Marchant 1992). It was raised to species status as *Drosera monticola* by Lowrie (2005). However, this combination is a *nomen invalidum* under Art. 33.4 of the *International Code of Botanical Nomenclature* (McNeill *et al.* 2006) because the page number given for the basionym was incorrectly quoted as 'pages 323–332' (the pagination range of the whole paper), rather than 'page 326' (the page of the basionym's protologue). This oversight is hereby rectified and the combination *Drosera monticola* formally validated.

Drosera monticola (Lowrie & N.G.Marchant) Lowrie, *stat. nov.*

Drosera stolonifera subsp. *monticola* Lowrie & N.G.Marchant, *Nuytsia* 8(3): 326 (1992). *Type*: Summit of Toolbrunup Peak, Stirling Range National Park, Western Australia, 14 November 1989, *P. Mann s.n.* (*holo*: PERTH 02642964).

References:

Lowrie, A. & Marchant, N.G. (1992). Four new *Drosera* taxa from south western Australia. *Nuytsia* 8(3): 323–332.

Lowrie, A. (2005). A taxonomic revision of *Drosera* section *Stolonifera* (Droseraceae), from south-west Western Australia. *Nuytsia* 15(3): 355–393.

McNeill, J., Barrie, F.R., Burdet, H.M., Demoulin, V., Hawksworth, D.L., Marhold, K., Nicolson, D.H., Prado, J., Silva, P.C., Skog, J.E., Wiersema, J.H. & Turland, N.J. (eds) (2006). *International Code of Botanical Nomenclature* (*Vienna Code*). Regnum Vegetabile vol. 146. (A.R.G. Gantner: Ruggell, Liechenstein.)

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Melaleuca marginata, a new name for *Melaleuca coronicarpa* (Myrtaceae)

During the preparation of a manuscript describing new species of *Astroloma* R.Br. from Western Australia, the first author had cause to examine type material of *Astroloma marginatum* Sond. obtained on loan from the National Herbarium of Victoria. Sonder (1845) had based the name on a sterile collection made by Preiss in the western wheatbelt, probably in the Toodyay–Bolgart area. When Bentham (1868) tentatively synonymised *A. marginatum* under *A. divaricatum* Sond. (= *A. epacridis* (DC.) Druce), he made the comment ‘if an *Astroloma* at all, may be this species’. His doubts were well-founded. Although the type specimen examined by the first author (originally from Sonder’s own herbarium) is indeed sterile, apart from what appear to be galled fruit, the detail of the leaf morphology, including the presence and distribution of oil glands, is clearly that of *Melaleuca coronicarpa* D.A.Herb. It seems likely that it was the combination of relatively indistinct oil glands, pungent leaf apices (a characteristic of all *Astroloma* species but not common in *Melaleuca*) and a similar, parallel leaf venation that misled Sonder as to the true identity of this collection.

In an enumeration of the species of *Melaleuca* in Australia by Craven and Lepschi (1999) the species was treated as *M. coronicarpa*, a name published by Herbert (1922). As *A. marginatum* is an earlier name than *M. coronicarpa*, the new combination *M. marginata* (Sond.) Hislop, Lepschi & Craven is made. While the type material of *Melaleuca marginata* is undeniably poor, and the name not particularly apt for the species, the case for conserving *M. coronicarpa* is weak. There is certainly no history of sustained usage in this case. The name does not seem to have been applied at all before the late 1980’s when B.A. Barlow (CANB, then working on *Melaleuca*) began to use it on specimen determinations.

Melaleuca marginata is a widespread and common species in the wheatbelt regions of Western Australia. It occurs from the Arrowsmith River district south to the Ongerup area and inland to the Koorda and Grass Patch districts and is found in open woodland, mallee-*Melaleuca* scrub, shrubland, low open heath, on clay, sand, red-brown loam, sandy loam over laterite, and sand over granite. The lateral, capitate, white-flowered inflorescences are followed by clusters of persistent, woody fruit and these features, together with the prickly nature of the leaves, are characteristic of the species.

Melaleuca marginata (Sond.) Hislop, Lepschi & Craven, *comb. nov.*

Astroloma marginatum Sond. in Lehm., *Pl. Preiss.* 1: 299 (1845). *Type*: In solo glareoso sterili silvae prope fontem Pitscharding, Victoria [according to Marchant (1990) Pitscharding Spring is an unknown locality in the county of Victoria, a nineteenth century name for an area which approximately corresponds to the modern shires of Toodyay and Victoria Plains in Western Australia], 20 March 1840, *L. Preiss* 471 (*holo*: MEL 2181123!).

Melaleuca coronicarpa D.A.Herb., *J. & Proc. Roy. Soc. Western Australia* 8: 35 (1922), as *Melalenca*. *Type*: Western Australia: Bruce Rock, on the road to Merredin, November 1920, *Wilson & Herbert* 152 (*holo*: PERTH 01638777!; *iso*: MEL!).

Notes. B.A. Barlow (unpublished data) has indicated that the name *M. cardiophylla* var. *parviflora* Benth. (Bentham 1867) is a synonym of *M. coronicarpa*. However, lectotypification of this name is clearly desirable as some of the syntypes are from localities well outside the geographic range of *M. marginata* and will almost certainly be referable to other taxa. The syntypes in question, all unseen by us, are: Western Australia: Swan River, *Drummond* 1st coll. *s.n.* (*syn*: K); Murchison river, *Oldfield s.n.* (*syn*: K); Shark Bay, *Denham s.n.* (*syn*: K); Dirk Hartog Island, *Milne s.n.* (*syn*: K); Bay of Rest, NW coast, *Cunningham s.n.* (*syn*: K).

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References

Bentham, G. (1867). *Flora Australiensis. Vol.* 3, p. 135 (Reeve: London.)

Bentham, G. (1868). *Flora Australiensis. Vol.* 4, p. 156-157 (Reeve: London.)

Craven, L.A. & Lepschi, B.J. (1999). Enumeration of the species and infraspecific taxa of *Melaleuca* (Myrtaceae) occurring in Australia and Tasmania. *Australian Systematic Botany* 12: 819–927.

Herbert, D.A. (1922). Contributions to the flora of Western Australia. No. 4. *Journal and Proceedings of the Royal Society of Western Australia* 8: 35–41.

Marchant, N.G. (1990). *In*: Short, P.S. (ed.), *History of systematic botany in Australasia*, p. 131–135 (Australian Systematic Botany Society: South Yarra, Vic.)

Sonder, O.W. (1845). Epacridaceae. *In*: Lehmann, J.G.C. (ed.) *Plantae Preissianae*. Vol. 1, p. 299 (Sumptibus Meissneri: Hamburg.)

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Corrections

Vol. 21(2)

On page 59, the paragraph under the heading *Notes* should be placed after the paragraph under the heading *Illustrations.* The pdf version has been corrected.

On page 71, the specific epithet for the new taxon *Stackhousia stratfordii* W.R.Barker & Cockerton should be corrected to *stratfordiae* to agree with the gender of the person after whom it is named, Ms Kirsty Stratford. The authors are grateful to the several people who so promptly informed us of the mistake and to the good humour with which Ms Stratford took the news of her new gender.

Vol. 20

On page 98, the subspecific epithet for the new taxon *Stylidium acuminatum* (Carlquist) Wege subsp. *meridionalis* Wege should be corrected to *meridionale* to agree with the neuter gender of *Stylidium.*

Eremophila koobabbiensis (Scrophulariaceae), a new, rare species from the wheatbelt of Western Australia

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Abstract

Chinnock, R.J. & Doley, A.B. *Eremophila koobabbiensis* (Scrophulariaceae), a new, rare species from the wheatbelt of Western Australia. *Nuytsia* 21(4): 157–162 (2011). *Eremophila koobabbiensis* Chinnock, *sp.nov.*, is described and illustrated. This rare species is known only from one area north of Moora and its conservation is discussed. It is also established in cultivation and its long-term survival is assured.

Introduction

When the monograph of *Eremophila* and allied genera was published (Chinnock 2007) one of the authors of this paper (RJC) was aware of a number of undescribed species in Western Australia that had been seen in the field or had been isolated from existing herbarium collections but were either inadequate for the preparation of accounts for publication, or were discovered too late to be included in the monograph. Andrew Brown (Department of Environment and Conservation, Western Australia) also drew attention to other new species of which he was aware. Since the publication of the monograph, two new taxa, *E. grandiflora* A.P.Br. & B.Buirchell and *E. densifolia* F.Muell. subsp. *erecta* A.P.Br. & B.Buirchell have been published (Brown & Buirchell 2007).

In this paper a new and rare species is described and illustrated. *Eremophila koobabbiensis* is known only from Koobabbie Farm north of Moora usually as small numbers of scattered plants and these have been protected and conserved by the property owners (A.B. Doley and the late J. Doley), both of whom have had a long interest in native plants and their conservation. The two areas where the populations of *E. koobabbiensis* occurred were fenced off from stock in 1986 and 1991 at the owners' expense and they were advised in 1999 that it was a new species. The species was listed as Declared Rare Flora in 2005 under the *Western Australian Wildlife Conservation Act 1950* and listed as critically endangered in 2009 under the *Environment Protection and Biodiversity Conservation Act 1999*. An interim recovery plan for the species was published by Douglas in 2007.

Cutting material was obtained from a number of plants on a visit to Koobabbie in 2001 (RJC) and plants are now well established and preserved in cultivation in South Australia and Victoria. Plants are also grown at the Botanic Gardens and Parks Authority (Kings Park, Perth) and an approved replanting translocation project has also occurred on Koobabbie Farm.

Eremophila koobabbiensis Chinnock, *sp. nov.*

Frutex erectus ramis (et foliis, sepalis) dense glandularo-pubescentibus cum longior eglandularo-pubescentibus; foliis imbricates, ternato-verticillatis vel subternato-verticillatis, oblongis ad linearo-ellipticis lobis in 1–2 paribus raro aliquot integris; floribus solitaribus, sessilibus; sepalis valvatis, aequalis, linearo-lanceolatis; corolla lilacina ad dilute malvina, eglandularo-pubescentia; fructu sicco, ovoideo ad late ovoideo, villoso.

Typus: Koobabbie Farm, north of Moora, Western Australia, September 2001, *A. Doley s.n.* (*holo*: PERTH 06114555; *iso*: AD, B, CANB, K, MEL, MO).

Eremophila sp. Koobabbie (R.J.Chinnock 9540), C.Douglas, B.Todd & A.Brown, *Koobabbie poverty bush (Eremophila koobabbiensis ms)*: *interim recovery plan, 2007–2012.*

Eremophila koobabbiensis Chinnock ms, Western Australian Herbarium, in *FloraBase*, http://florabase.dec.wa.gov.au [accessed 23 July 2011].

Erect compact shrub to 1.6 m tall. *Branches* terete, smooth or with a few very obscure tubercles, densely pubescent with numerous short glandular hairs and longer, thin, often flexuose, white largely eglandular hairs. Leaves sessile, in whorls of 3 although often with one leaf displaced slightly further down the stem, erect, imbricate, obscuring branch, especially towards branch tips, oblong to linear-elliptic, distinctly lobed or rarely with a few entire; lobes in 1 or 2 pairs, obtuse, apex obtuse, 5.5–7 (–10.5) × 1.8–2.5 mm, surfaces faintly verrucose, shortly glandular-pubescent with longer thin weak eglandular hairs on margins and adaxial surface, pale green. *Flowers* 1 per axil, sessile. *Sepals* 5, valvate, linear-lanceolate, posterior one slightly shorter than other 4, acute, base distinctly fleshy, entire, with two rows of elongate translucent tubercles either side of midrib, 3.5–5 × 0.7–1 mm, outer surface with short glandular and longer eglandular ones, inner surface glandular-pubescent. *Corolla* 8–10 mm long, lilac to pale mauve, whitish on lower side outside and in the tube on lower side, lowermost lobe and inside of tube with irregular purple blotches; outside surface of lobes and tube eglandular pubescent, hairs slender; inside surface of upper 4 lobes glabrous, lowermost lobe prominently bearded with a dense mat of white hairs extending down the tube below it; glabrous elsewhere; tube constricted in lower part, narrow cylindrical, campanulate above; lobes obtuse. *Stamens* 4, included but upper two often extending just beyond throat, filaments white, glabrous; anthers blue, glabrous. Ovary oblong, 4-locular, with 1 ovule per locule. *Fruit* dry, ovoid to broadly ovoid, beaked, 3.5–4.5 × 2.5–3.5 mm; exocarp adhering to endocarp, densely white villous, with longer appressed eglandular hairs and short, obscure glandular ones; endocarp woody. *Seed c.* 2 × 0.7 mm, pale buff. (Figures 1, 2)

Other specimen examined. WESTERN AUSTRALIA: Koobabbie, 3 Dec. 2001, *R.J.Chinnock* 9540 (AD, PERTH).

Distribution and ecology. This species appears to be restricted to Koobabbie farm north of Moora where it has persisted in remnant degraded open *Eucalyptus* woodland of *E. salubris* (gimlet) and *E. salmonophloia* (Salmon gum) as seed presumably since 1906, when clearing commenced, until 1986 and 1991 when the areas were fenced off from livestock. Another *Eremophila* of conservation significance, *E. sargentii* (Priority Two), also occurs close to *E. koobabbiensis* at one site.

Flowering period. Although the main flowering occurs in spring during August and September, flowers occur sporadically at other times of the year.

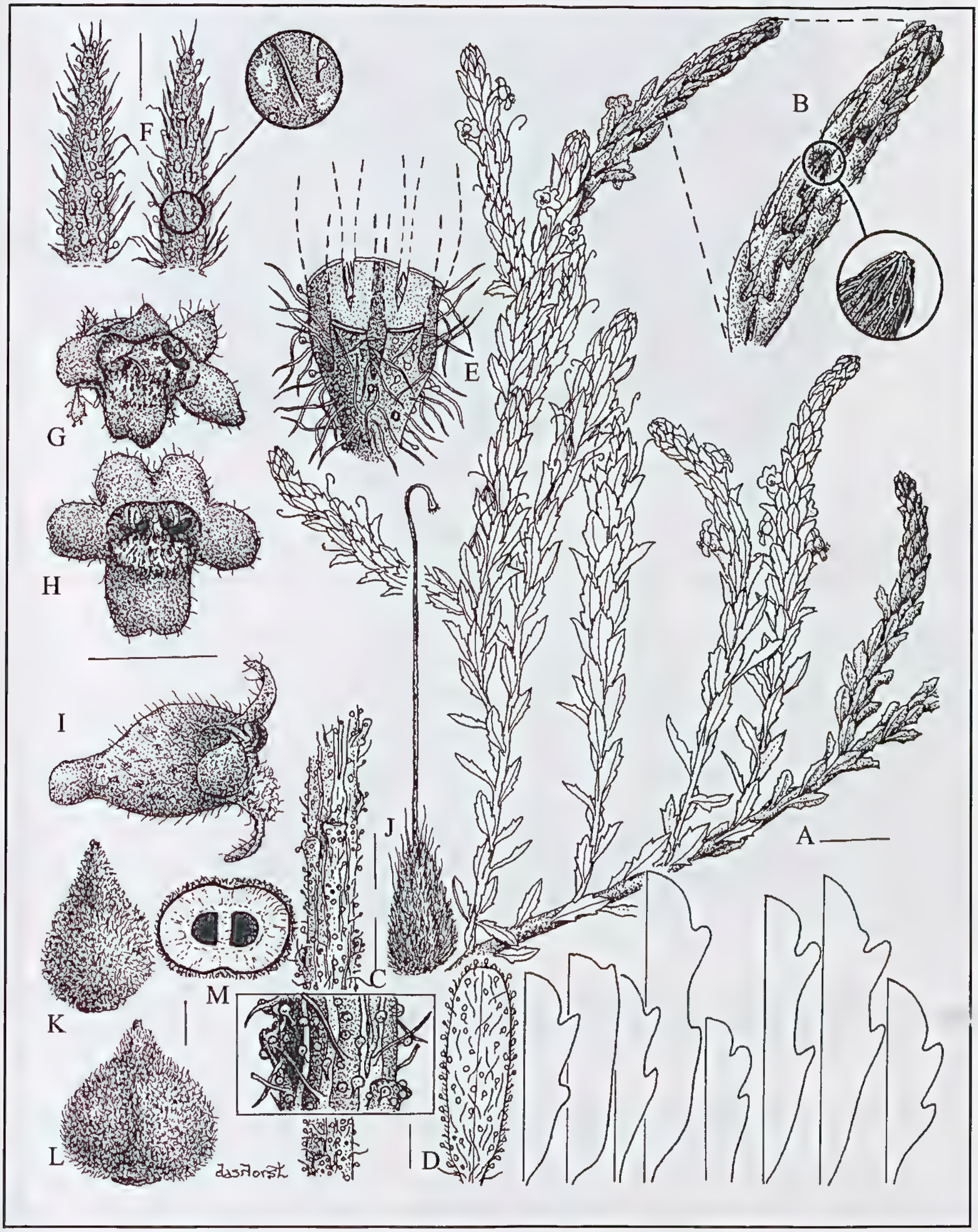

Figure 1. *Eremophila koobabbiensis*. A – branching arrangement; B – terminal portion of branch showing imbricate leaves and enlargement showing hairs; C – portion of branch with enlargement showing indumentums of long eglandular hairs and shorter glandular ones; D – leaf, with outlines showing variations in lobing and lobes restricted to the distal two thirds; E – basal portion of calyx showing valvate arrangement of sepals; F – outer and inner surface of sepal with enlargement showing glandular hairs and translucent spotting; G, H – front view of corolla; I – side view of corolla; J – gynoecium; K, L – side and front view of fruit; M – cross-section of bilocular fruit. (A–M, based on the type specimen). Scale bars: A = 5 mm; C = 1.5 mm; D = 1 mm; E, F = 1 mm; G–I = 5mm; J = 1 mm; K–M = 1 mm.

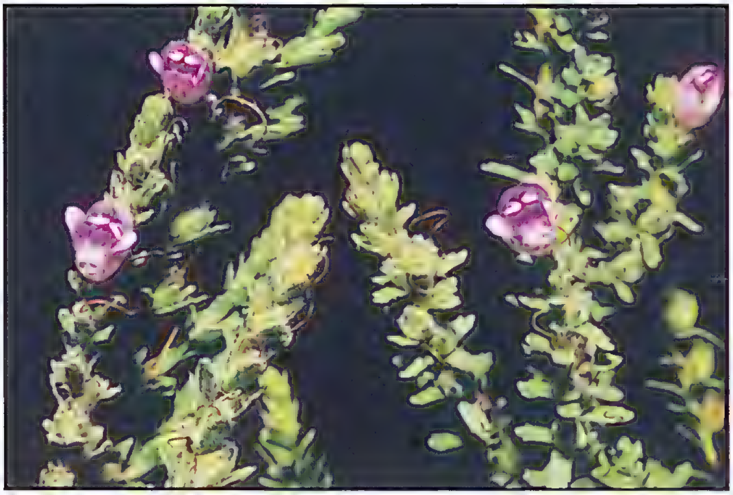

Figure 2. *Eremophila koobabiensis* (cultivated, ex *Chinnock* 9540)

Conservation status. The species is listed as *Declared Rare Flora* (Threatened) under the *Western Australian Wildlife Conservation Act 1950* and it is currently considered critically endangered.

When one of the authors (RJC) visited Koobabbie Farm in December 2001 there were seven mature plants occurring in two small populations about 3 kilometres apart, but in an interim recovery report published in 2007 (Douglas *et. al.*) only four mature plants were reported as occurring in one population. However, this is incorrect and until recently the two small populations still existed. A third natural population was located by one of us (ABD) in 2009 on Koobabbie Farm about one kilometre south-west from the population near Mamboobie road. This population consisted of at least 90 flowering plants to 0.7 m tall so they were thought to have been up to five years old. Unfortunately, this population was destroyed by rabbits later in the year after discovery through browsing and ring barking. Nevertheless this location should hold a rich seed resource in the soil and rabbit proofing of the site would be desirable to ensure any future seedling recruitment in favourable seasons would be protected.

A translocation of 74 young plants, propagated by cutting methods, occurred on Koobabbie Farm in July 2008 and currently 46 plants have established. These plants now range in height from 0.6–0.7 m.

Derivation of epithet. Taken from the farm to which this species is thought to be restricted.

Classification. Eremophila koobabbiensis belongs to *E.* section *Australophilae* and appears to be closest to *E. pinnatifida* Chinnock (Figure 3) which occurs further to the south-east near Dalwallinu.

The two species are well defined and readily distinguished. The terminal branches in *E. koobabbiensis* (including the appressed leaves) are of uniform width or slightly tapering towards the apices ranging from 4–5 mm broad (Figure 1B) whereas in *E. pinnatifida* they are distinctly dilated at the apices, 10–14 mm broad resulting from clustering of the developing terminal leaves (Figure 3B). The leaves of the two species are also markedly different. *Eremophila koobabbiensis* has leaves with few, usually irregularly arranged lobes which are cut into the lamina up to one third the way to the midrib. The

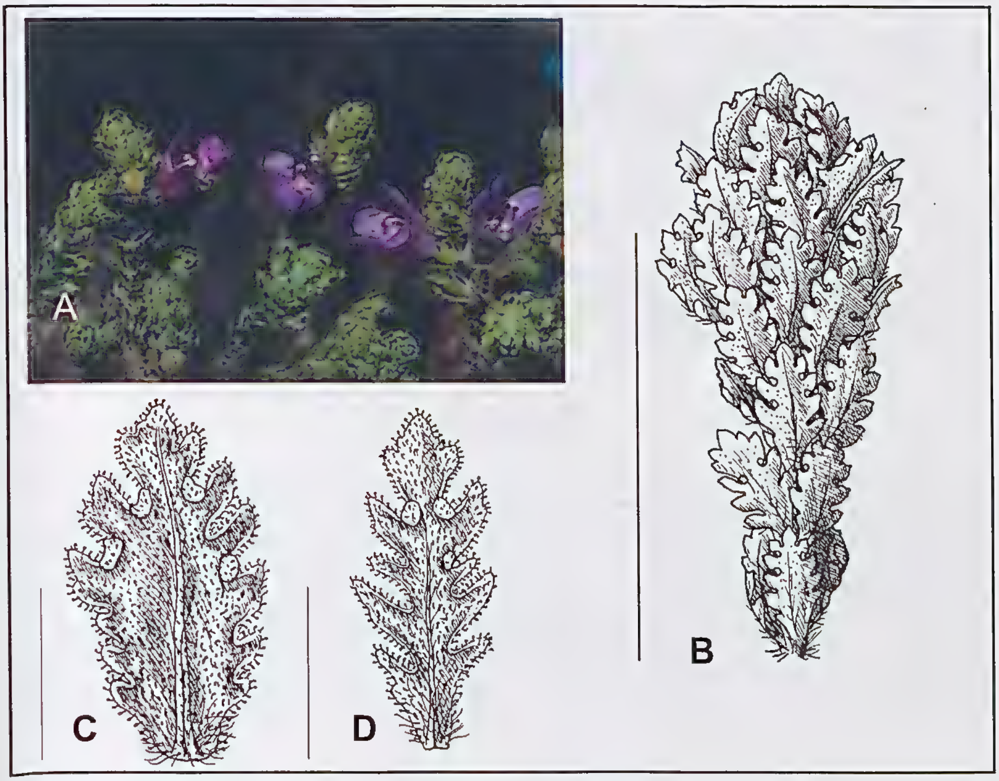

Figure 3. *Eremophila pinnatifida.* A – flowering branches (*Chinnock* 7966); B – dilated terminal portion of branch; C, D – undersurface of leaves showing the deeply dissected lobes and raised reflexed portions of lamina at the base of the sinus between some adjacent lobes. B–D (*Chinnock* 7971). Scale bars: B = 20 mm; C = 3 mm; D = 2.5 mm.

lobes are restricted to the upper two thirds of the leaf but mostly in the distal half. Occasionally a few leaves on a branch may be entire. The leaf of *E. pinnatifida* is uniformly lobed along both margins to near the leaf base and the lobes are cut into the lamina at least half way to the leaf midrib. In addition the portion of lamina at the base of the sinus between adjacent lobes is often reflexed and distinctly raised on the lower surface (Figure 3C, D).

In the monograph (Chinnock 2007), *E. koobabbiensis* falls within the Synopsis for sect. *Australophilae* (p. 230) in Group A.

A Leaves in distinct whorls of 3–5

1. Leaves flattened: 32, *ternifolia*, 36. *densifolia*, 46. *scaberula*, 49. *pinnatifida*, 49A. *koobabbiensis*
2. Leaves subterete: 21, *chamaephila*, 31. *verticillata*, 33. *veronica*, 34. *caerulea*, 47 *sargentii*

The key to species (Chinnock 2007: 231) can be adjusted as follows:

15 Leaves distinctly lobed
Leaves deeply lobed, lobes extending to near leaf base,
consisting of 4 or more pairs; corolla 18–25 mm long, pale to dark purple .... **49. *E. pinnatifida***
Leaves shallowly lobed, lobes scattered and mostly restricted to the distal third to
half of the leaf, consisting of 1 to 2 pairs; corolla 8–10 mm long, pale lilac to
pale purple .... **49A. *E. koobabbiensis***

15. Leaves entire.. **16**

Note. The authors prefer Koobabbie eremophila as a common name rather than Koobabbie poverty bush. This latter name adopted in the Interim Recovery Plan by Douglas *et al.* (2007) is considered inappropriate as 'poverty bush' has normally been applied to non-palatable eremophila species in the pastoral areas that tend to increase as land becomes degraded or over-grazed.

Acknowledgements

We wish to thank Mr Gilbert Dashorst for preparing the illustration of *Eremophila koobabbiensis* and Dr Hellmut Toelken for checking the Latin.

References

Brown, A.P. & Buirchell, B. (2007). *Eremophila densifolia* subsp. *erecta* and *E. grandiflora* (Myoporaceae), two new taxa from south-west Western Australia. *Nuytsia* 17: 81–86.

Chinnock, R.J. (2007). *Eremophila* and allied genera: a monograph of the plant family *Myoporaceae*. (Rosenberg: Kenthurst, NSW.)

Douglas, C., Todd, B. & Brown, A. (2007). Koobabbie poverty bush (*Eremophila koobabbiensis* ms): interim recovery plan, 2007–2012. Interim recovery plan no. 233. (Department of Environment & Conservation: Kensington, WA.)

Western Australian Herbarium (1998–). *FloraBase – The Western Australian Flora.* Department of Environment and Conservation. http://florabase.dec.wa.gov.au/ [accessed July 2011]

Nuytsia 21(4): 163–176 (2011)

A reinstatement and a new combination in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae)

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Abstract

Hislop, M. A reinstatement and a new combination in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae). *Nuytsia* 21(4): 163–176 (2011). The group of species synonymised by Bentham (1868) under *Leucopogon revolutus* R.Br. are re-examined and found to be heterogeneous. As a result *L. rubricaulis* R.Br. is reinstated. Two morphotypes identified within *L. obovatus* (Labill.) R.Br. (erroneously treated by Bentham as *L. revolutus*) are described as subspecies and the combination *L. obovatus* (Labill.) R.Br. subsp. *revolutus* (R.Br.) Hislop is here published. Descriptions and illustrations are provided for the three taxa treated and their distributions are mapped. Lectotypes are designated for *L. capitellatus* DC. var. *sparsiflorus* Sond., *L. revolutus*, *L. rubricaulis* and *L. villosus* R.Br.

Introduction

There has been long-standing confusion surrounding the taxonomy of several similar-looking *Leucopogon* R.Br. taxa from the south coast of Western Australia, which can be broadly characterized by their relatively long, narrow leaves with distinctly recurved or revolute margins. *Styphelia obovata* Labill. was the first name published (Labillardière 1805) in the group, and that species is also notable in being the first endemic Western Australian epacrid to be described. Five years later Robert Brown (1810) transferred it to his new genus *Leucopogon*. In the same publication Brown described another three species with similar foliar morphologies, *L. revolutus* R.Br., *L. rubricaulis* R.Br. and *L. villosus* R.Br., based on collections he made at King George Sound [Albany] and from two localities east of where the town of Esperance is now sited. Bentham (1837) added *L. angustatus* Benth. to the group, which was later followed by the infraspecific taxon, *L. angustatus* var. *hirsutus* Sond. (Sonder 1845). In his treatment of *Leucopogon* in *Flora Australiensis* however, Bentham (1868) not only changed his mind about the separate status of *L. angustatus*, but decided that the 'group' as a whole was better treated as a single variable species. While apparently recognising that *L. obovatus* had priority, he preferred to apply the name *L. revolutus*, which he thought more appropriate, and treated all of the others as synonyms. Blackall and Grieve (1981) continued to recognise only one species but, realizing that Bentham had erred in using *L. revolutus*, they returned to *L. obovatus*. Since the late 1990s both names have been included on the *Census of Western Australian Plants*, although in the absence of any published means of distinguishing between the two, they have been applied more or less arbitrarily.

The current paper revisits the taxonomy of this problematic group in the light of a much larger specimen base than was available to earlier workers, and after reference to the relevant type specimens.

Methods

This study was based on an examination of dried specimens housed at PERTH. The details of the methods used to measure plant parts and make other morphological observations are the same as those described previously (Hislop 2009a), except in relation to the inflorescence character of *Leucopogon rubricaulis,* which is of the type described for the *L. gracilis* group (Hislop 2009b). The basal point of the terminal inflorescence for that species is therefore taken to be the lowest axil from which a single flower arises (below which multi-flowered axillary inflorescences are usually present), and for axillary inflorescences, the point of attachment to the main axis. The fertile bract measurements are taken from the upper three inflorescence nodes only.

The distribution maps were compiled using DIVA-GIS Version 5.2.0.2 and based on PERTH specimen data.

Taxonomy

Leucopogon obovatus (Labill.) R.Br., *Prodr. Fl. Nov. Holl.* 542 (1810). *Styphelia obovata* Labill. *Nov. Holl. Pl.* 1: 48 (1805). *Type*: 'in terrâ Van-Leuwin' [near Esperance, Western Australia], 13–18 December 1792, *J.J.H. Labillardière s.n.* (*holo*: FI-W118462, image seen).

Erect, robust *shrubs* to *c.* 2.5 m high and 2 m wide, usually multi-stemmed at the base and at least sometimes with a fire-tolerant rootstock. Young *branchlets* with a moderately dense to dense indumentum, either monomorphic with short hairs to *c.* 0.1 mm or dimorphic with the layer of short hairs overtopped by a longer layer, 0.3–1.0 mm long, the short hairs patent, ± straight or slightly curved, the longer ones variously orientated, straight to distinctly curved. *Leaves* spirally arranged, mostly variously antrorse to ± patent, occasionally shallowly retrorse, shape very variable depending to a significant extent on the degree of curvature, from narrowly ovate or narrowly triangular to linear, oblong, elliptic or narrowly elliptic, to obovate, narrowly obovate or narrowly obtriangular, 6–23 mm long, 0.6–4.5 mm wide; apex obtuse to acute with a ± recurved callus point; base cuneate to rounded; petiole moderately well-defined, greenish-yellow to pale brown, 0.2–0.6 mm long, usually hairy at least in part, less often glabrous; lamina 0.15–0.25 mm thick, curvature variable, adaxial surface convex with the margins varying from slightly recurved with the abaxial surface visible throughout to revolute and the abaxial surface completely concealed, longitudinal axis ± straight; surfaces discolorous; adaxial surface shiny with a moderately dense to dense indumentum of short, tubercle-based, antrorse hairs, these often abraded on older leaves, the surface remaining verrucose, the venation usually quite distinct with 3–5 sunken veins evident, less often indistinct or barely evident; abaxial surface paler, usually hairy with either a short monomorphic indumentum or the indumentum variable and including some conspicuous, long hairs, sometimes glabrous, with 5–7 flat or slightly raised primary veins, the midrib usually somewhat more prominent than the others; margins either completely glabrous or minutely ciliolate with coarse, antrorse hairs to *c.* 0.05 mm long. *Inflorescences* erect, terminal and upper-axillary, usually aggregated into dense conflorescences; axis 3–28 mm long with 3–15 flowers, terminating in a bud-like rudiment or occasionally an attenuate point; axis indumentum of dense hairs 0.04–0.10 mm long; flowers erect and sessile. *Fertile bracts* ovate or broadly ovate, 0.5–1.3 mm long, 0.6–1.2 mm wide, obtuse or subacute. *Bracteoles* ovate, 1.0–2.1 mm long, 0.8–1.5 mm wide, obtuse to subacute, keeled; abaxial surface with a sparse or moderately dense indumentum of short, often retrorse hairs, these sometimes confined to the keel, becoming scarious towards the margins; adaxial surface shortly hairy at least in the upper half; margins ciliolate. *Sepals* ovate or broadly ovate, 1.7–3.0 mm long, 1.1–1.8 mm wide, obtuse or occasionally subacute; abaxial surface usually hairy with a sparse to dense indumentum of short hairs, occasionally ± glabrous, the central portion pale greenish or straw-coloured, sometimes with reddish tinges towards the apex, becoming scarious towards the margins, the venation obscure; adaxial surface shortly hairy at least in the upper half; margins ciliate with hairs to *c.* 0.2 mm long. *Corolla tube* white, campanulate, or broadly so, shorter than the sepals, 1.0–2.0 mm long, 1.2–2.2 mm wide, glabrous externally and internally. *Corolla lobes* white, much longer than the tube (ratio = 1.4–2.5:1), widely spreading from the base and recurved, 2.2–3.5 mm long, 0.7–1.4 mm wide at base, glabrous externally, densely bearded internally; indumentum white, 0.5–1.0 mm long near apex; glabrous tip 0.2–0.3 mm long. *Anthers* partially exserted (by *c.* 7/8 of their length) to fully exserted from the tube, 1.2–2.2 mm long, recurved towards the apex; sterile tips white, usually fairly conspicuous, 0.3–0.6 mm long. *Filaments* terete, 0.7–1.4 mm long, attached 1/2–2/3 above anther base, adnate to tube just below sinus. *Ovary* ellipsoid, globose or depressed-globose, 0.5–0.8 mm long, 0.5–1.0 mm wide, glabrous, (4)5-locular. *Style* 0.3–0.8 mm long, either well-differentiated from the ovary apex, or poorly so and tapering ± evenly from apex to stigma, included within the corolla tube; *stigma* ± expanded and obscurely lobed; *nectary* annular, 0.25–0.45 mm long, entire or shallowly lobed, glabrous. *Fruit* broadly obovoid, globose to depressed-globose, 1.9–2.3 mm long, 1.9–2.6 mm wide, glabrous, with smoothly rounded shoulders, longer than the calyx, mesocarp well-developed, manifesting as an irregular, raised reticulum on dried specimens; style persistent.

Notes. *Leucopogon obovatus* is a robust, floriferous plant with a distribution of at least 900 km along the southern coast of Western Australia. It is among the State's most frequently collected epacrids, and one which exhibits considerable variation. An examination of the large holding of this taxon (*c.* 400 specimens) at PERTH, indicates that two geographically-based morphotypes are present but with intermediates where their ranges overlap. The main differences indicative of this divergence are vegetative with some support from a correlating floral character. Infraspecific rank is chosen here as the best reflection of the nature and geographical distribution of these differences and the fact that a significant level of intergradation occurs in the relatively small area where the two are sympatric.

Key to subspecies of *Leucopogon obovatus*

1. Branchlet indumentum monomorphic, with short hairs to *c.* 0.1 mm long, but usually less; leaf shape, when recurved margins are flattened, obovate, narrowly obovate, elliptic or narrowly elliptic, the widest point at or above the middle; leaf abaxial surface usually with short hairs only, less often glabrous; style 0.5–0.8 mm long (near-coastal areas between Denmark and Israelite Bay).. subsp. **obovatus**

1: Branchlet indumentum dimorphic, with a layer of short hairs overtopped by a distinctly longer layer, the latter 0.3–1.0 mm long; leaf shape, when recurved margins are flattened, narrowly ovate or narrowly elliptic (usually very narrowly so), the widest point at or below the middle; leaf abaxial surface usually with a mixture of long and short hairs, occasionally with short hairs only or glabrous; style 0.3–0.5 mm long (Margaret River area to Albany and inland as far as the Stirling Range) .... subsp. **revolutus**

a. Leucopogon obovatus (Labill.) R.Br. subsp. obovatus

Young *branchlets* with a monomorphic indumentum of short hairs to *c.* 0.1 mm long. *Leaves* in natural posture linear, oblong, obovate, narrowly obovate or narrowly obtriangular, when recurved margins are flattened, obovate, narrowly obovate, elliptic or narrowly elliptic; abaxial surface with short hairs only, or sometimes glabrous. *Style* 0.5–0.8 mm long, always well-differentiated from the ovary apex. (Figures 1, 4B)

Selected specimens examined. WESTERN AUSTRALIA: Michaelmas Island, King George Sound, Albany, Sep. 1975, *I. Abbott* 47 (PERTH); Point Charles, Fitzgerald River Reserve [National Park], 5 Aug. 1970, *M.I.H. Brooker* 2738 (NSW, PERTH); Cape Le Grande National Park. Between Rossiter Bay carpark and the Bird Sanctuary, 24 Sep. 1985, *M. Carter* 142 (NSW, PERTH); near campsite, Bald Island, 16 Oct. 2003, *J.A. Cochrane & S. Comer* 28 (PERTH); Lort River, *c.* 200 m downstream of South Coast Highway, 16 Nov. 1993, *B.J. Conn* 4002 & *A.N.L. Doust* (MEL, NSW, PERTH); carpark at lookout, Tagon Bay, Cape Arid National Park, 7 Oct. 2003, *D.M. Crayn* 672, *K.A. Kron & A.J. Perkins* (NSW, PERTH, WFU); Hillman Street, Spencer Park [Albany], 14 Mar. 1989, *E.J. Croxford* 5414 (PERTH); Granite quarry, 2 km W of Marra Bridge, Hassell Highway, E of Albany, 23 Sep. 1987, *E.J. Croxford* 5937 (PERTH); environs of camping area, Waychinicup National Park, close to mouth of Waychinicup River, 26 Aug. 2006, *M. Hislop* 3636 (CANB, PERTH); Frenchman Bay, Albany, 1 km SE of Albany, 26 Oct. 1985, *N. Hoyle* 1341 (CANB, PERTH); Middle Island, Recherche Archipelago, 9 May 1991, *G.J. Keighery* 12369 (CANB, PERTH); Oldfield River on S side, 13 km WSW of Munglinup, *c.* 100 m W of crossing at intersection of Oldfield River and Coxall Rd, 28 Oct. 1998, *M.N. Lyons & S.D. Lyons* 3578 (PERTH); Millers Point, Beaufort Inlet, 18 Oct. 1964, *K.R. Newbey* 1520 (PERTH); Mylies Beach campsite area, Fitzgerald River National Park, 14 July 1982, *J.M. Powell* 1800 (CANB, K, L, MEL, NSW, PERTH); near Little Tagon Bay, Cape Arid National Park, 17 July 1982, *J.M. Powell* 1842 (CANB, K, L, MEL, NSW, PERTH); Stokes Inlet National Park, 20 July 1982, *J.M. Powell* 1883 (CANB, HO, K, L, MEL, NSW, PERTH); coast immediately W of West Cape Howe [W of Denmark], 26 July 1982, *J.M. Powell* 1975 (CANB, K, NSW, PERTH); on Condingup Hill *c.* 69 km E of Esperance, 1 Oct. 1970, *R.A. Saffrey* 1272 (PERTH); end of Rabbit Proof Fence, Starvation Bay, 75 km SE of Ravensthorpe, S of Springdale Rd, 19 Aug. 2001, *A. Williams* 305 (PERTH); Bremer Bay, 1 Oct. 1966, *P.G. Wilson* 4300 (CANB, NSW, PERTH).

Distribution and habitat. Widely distributed in near coastal localities between West Cape Howe and Israelite Bay (Figure 2), in the Esperance Plains and Jarrah Forest IBRA bioregions (Department of the Environment, Water, Heritage and the Arts 2008). Grows mostly on sand or sandy loam soils in heath or low woodland. It is frequently a dominant taxon on coastal dunes but also occurs over granite, limestone or quartzite and occasionally on subsaline flats.

Phenology. Flowers and/or fruit are present during much of the year, but with a flowering peak between July and October.

Conservation status. A widespread and common taxon.

Notes. The subspecies retain their differences across most of the wide range of *L. obovatus*. However in the Albany–Denmark area where their distributions overlap the two are quite frequently difficult to separate. In this area plants may have a morphology that is quite typical of one or the other subspecies (e.g. *J.M. Powell* 1975 & *I. Abbott* 47 for subsp. *obovatus* or *P. Foreman* 62 & *K. Baker* 10 for subsp. *revolutus*) or be intermediate between them (e.g. *C.A. Hortin* 6/59.4, *L.J. Pen* LJP 56 & *N. Gibson*

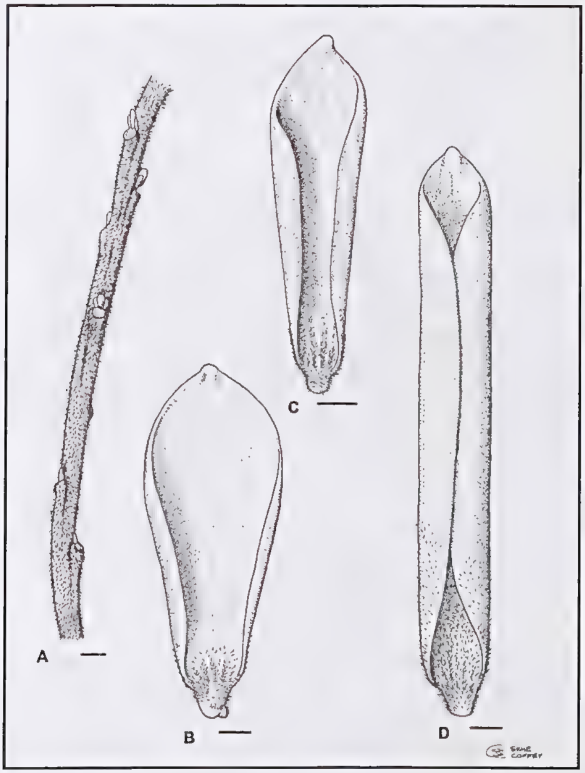

Figure 1. *Leucopogon obovatus* subsp. *obovatus*. A – indumentum on young branchlet; B–D – leaf variation, abaxial surface. Scale bars = 1 mm. Drawn by Skye Coffey from *M.N. Lyons & S.D. Lyons* 3578 (A), *J.M. Powell* 1842 (B), *E.J. Croxford* 5414 (C), *E.J. Croxford* 5937 (D).

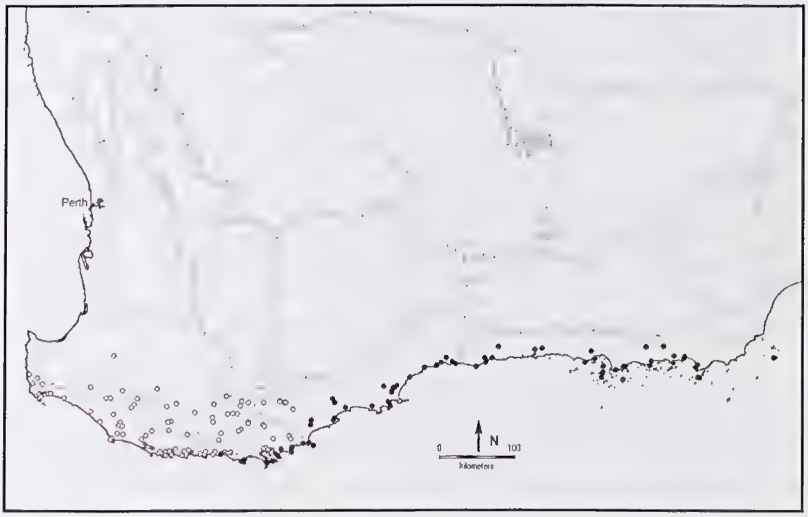

Figure 2. Distribution of *Leucopogon obovatus* subsp. *obovatus* (●) and *L. obovatus* subsp. *revolutus* (○) in southern Western Australia.

& M. Lyons 738). These intermediates generally have the leaf shape of subsp. *revolutus*, although always lacking long hairs on the abaxial surface. The branchlet indumentum may be of two kinds: either mostly short but with a few irregularly distributed, longer hairs, or less often monomorphic and then with a hair length longer than normal for subsp. *obovatus*.

b. Leucopogon obovatus (Labill.) R.Br. subsp. **revolutus** (R.Br.) Hislop, *comb. et stat. nov.*

Leucopogon revolutus R.Br., *Prodr. Fl. Nov. Holl.* 542 (1810). *Styphelia revoluta* (R.Br.) Spreng., *Syst. Veg.* 1: 657 (1824). *Type*: King George Sound [Western Australia], December 1801–January 1802, *R. Brown s.n.* (*lecto*, here designated: BM 001040176, image seen); Lucky Bay [E of Esperance, Western Australia], January 1802, *R. Brown s.n.* (excluded *syntypes*: K 000348369, K 000348370, images seen) = *L. obovatus* subsp. *obovatus*; Goose Island [Recherche Archipelago, Western Australia], May 1803, *R. Brown s.n.* (excluded *syntypes*: BM 001040177, K 000348374, K 000348377, images seen) = *L. obovatus* subsp. *obovatus*.

[*Styphelia obovata* Labill. var. *angustior* F.Muell., *Fragm.* 6: 31 (1867). *Type*: none cited.]

[*Styphelia obovata* Labill. var. *angustissima* F.Muell., *Fragm.* 6: 31 (1867). *Type*: none cited.]

Young *branchlet* indumentum dimorphic, with a layer of short hairs overtopped by a distinctly longer layer, 0.3–1.0 mm long. *Leaves* in natural posture linear, oblong, narrowly ovate or narrowly triangular, when recurved margins are flattened, narrowly ovate or narrowly elliptic; abaxial surface usually with a mixture of short and obviously longer hairs, or sometimes glabrous. *Style* 0.3–0.5 mm long, either fairly well-differentiated from the ovary apex or tapering ± smoothly from the ovary apex to the stigma. (Figure 3)

Selected specimens examined. WESTERN AUSTRALIA: parking area at start of track up Mt Chudalup, 200 m from Wheatley Coast Highway [Rd], 16 km SSW of Northcliffe, 9 Oct. 1997, *E.A. Brown* 97/255 *& G. Taaffe* (CHR, NSW, NY, PERTH, UNSW); intersection of Caves Rd and Bussell Highway [N of Augusta], 20 m from road, 11 Oct. 1997, *E.A. Brown* 97/270 *& G. Taaffe* (CANB, NSW, NY, PERTH, UNSW); 20.6 km W of Denmark on Denmark–Walpole Rd, 26 Aug. 1986, *A.R. Chapman* 385 (NSW, NY, PERTH); 1 km W of Hay River on Spencer Rd [SW of Mt Barker], 29 Aug. 1986, *A.R. Chapman* 406 (HO, NSW, PERTH); Lake Seppings, Albany, 30 Sep. 1984, *R.J. Cranfield* 4951 (HO, PERTH); 2 km SSE of Quinninup, 11 Oct. 1999, *R.J. Cranfield* 14040 (CANB, PERTH); carpark at entrance to Treetop Walk, Valley of the Giants, Walpole-Nornalup National Park, 10 Oct. 2003, *D.M. Crayn* 707, *K.A. Kron & A.J. Perkins* (NSW, PERTH, WFU); Willyung Hill, about 12 km N of Albany, 23 Sep. 1984, *D.B. Foreman* 825 (AD, MEL, NSW, PERTH); N part of Porongurup National Park, 1.5 km W of the ranger's residence along scenic drive, 21 Oct. 1991, *W. Greuter* 23062 (PERTH); South Sister Nature Reserve, NE of Albany, along E boundary of southern block, 17 Nov. 2003, *M. Hislop* 3095 (NSW, PERTH); Transect 5, Lake Noobijub. On SE edge of lake, *c.* 450 m around from inlet drain, *c.* 25 km NW of Rocky Gully, 31 Oct. 2001, *B. Muir* 95 (PERTH); [Mount] Toolbrunup, Stirling Range National Park, 14 Aug. 1981, *B.F. Palser* 49 (PERTH); Boat Harbour Rd, *c.* 4 km SW of South Coast Highway, 25 July 1982, *J.M. Powell* 1961 (K, L, NSW, PERTH); near the Knoll and Nornalup Inlet, Walpole–Nornalup National Park, 14 Aug. 1979, *J.M. Powell* 1163 (BISH, CANB, K, L, NSW, PERTH); Blue Lake Rd, 12.3 km from junction with Denmark–Mount Barker Rd, 24 July 1982, *J.M. Powell* 1955 (CANB, K, L, MEL, NSW, PERTH); Geekabee Hill, W of Cranbrook, 4 Aug. 1986, *J.M. Powell* 2434A (HO, NSW, PERTH); 4 km N of Augusta, at turn-off to Yallingup, 24 Aug. 1986, *J.M.*

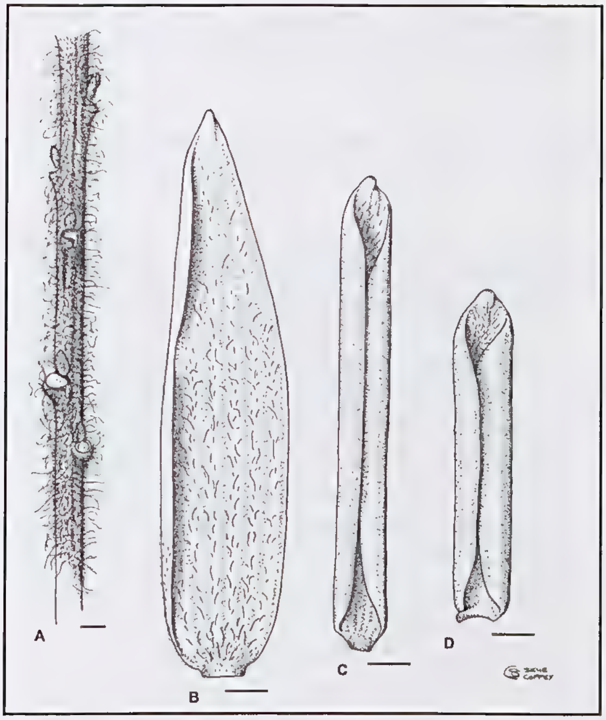

Figure 3. *Leucopogon obovatus* subsp. *revolutus*. A – indumentum on young branchlet; B–D – leaf variation, abaxial surface. Scale bars = 1 mm. Drawn by Skye Coffey from *R.J. Cranfield* 14040 (A), *J.M. Powell* 2646 (B), *J.M. Powell* 1961 (C), *W. Greuter* 23062 (D).

Powell 2612 (HO, NSW, PERTH); Windy Harbour area, 1–2 km E of Pt D'Entrecasteaux lighthouse, 25 Aug. 1986, *J.M. Powell* 2646 (NSW, NY, PERTH); Scott National Park, SW corner, 12 Oct. 1990, *C.J. Robinson* 185 (PERTH); Napier Creek crossing along the Chester Pass Rd [NE of Albany], 1 Sep. 1986, *P.S. Short* 2598, *M. Amerena & B.A. Fuhrer* (MEL, NSW, PERTH).

Distribution and habitat. Extends from a little south of Margaret River to the Albany area and then north as far as Wheatley [N of Manjimup] and the Stirling Range (Figure 2). This places it mainly in the Warren and Jarrah Forest IBRA bioregions (Department of the Environment, Water, Heritage and the Arts 2008) with a limited occurrence in the far west of the Esperance Plains bioregion. Grows in deep sand, sandy loam or less often loam soils, sometimes over laterite or granite, and as a component of dry or occasionally winter-wet heath, woodland or forest.

Phenology. Mostly flowers between late July and the end of October.

Conservation status. A widely distributed and common taxon in the wetter parts of the south-western corner of Western Australia

Affinities. In addition to the characters used to separate the two in the key above, it is noteworthy that the leaves of subsp. *revolutus* usually have a noticeably longer and narrower aspect than those of the typical subspecies. This subspecies may also be mistaken for *L. capitellatus* DC., another member of the *L. australis* group (*sensu* Hislop & Chapman 2007). These two are sympatric throughout the range of subsp. *revolutus* but there is no evidence of hybridization or intergradation. The two can be distinguished using the foliar characters in Table 1.

Table 1. Morphological differences between *Leucopogon obovatus* subsp. *revolutus* and *L. capitellatus*

	L. obovatus* subsp. *revolutus	***L. capittellatus***
Leaf curvature	Adaxial surface usually strongly convex, the margins usually manifestly recurved or revolute, and obscuring at least a portion of the abaxial surface, although in a few leaves the abaxial surface may be visible throughout.	Adaxial surface ± flat to slightly concave, if the margins somewhat recurved, then the abaxial surface still clearly visible throughout.
Leaf margins	Apparently glabrous or sometimes minutely ciliolate under high magnification, with hairs to 0.05 mm long.	Manifestly ciliate with hairs 0.05–0.20 mm long.
Leaf apex	Obtuse or rather abruptly contracted to a blunt point.	Smoothly attenuate.

Notes. In his treatment of *Leucopogon obovatus* (as *Styphelia obovata*) in *Fragmenta Phytographiae Australiae*, Mueller (1867) listed two varieties, var. *angustior* F.Muell. and var. *angustissima* F.Muell. Neither of these names were widely adopted. The former does not appear at all in the subsequent literature, and while the latter is included in the online Australian Plant Name Index (APNI: Australian National Botanic Gardens 1991–), the name has apparently never been used in Western Australia. The fact that no types were nominated and that efforts to find potential type specimens have proven fruitless, suggests that it may well never have been the author's intention to formally publish these varieties. However, to judge by Mueller's scant descriptions, and the localities given, it is probable that both are referrable to *L. obovatus* subsp. *revolutus*.

Typification. Brown based the name *Leucopogon revolutus* on collections he made at King George Sound [Albany], Goose Island and Lucky Bay [both east of Esperance]. The single specimen from the former locality at the Natural History Museum, London is chosen as the lectotype for that name. Although both subspecies occur in the Albany area, Brown's collection from King George Sound clearly has the characteristic, dimorphic indumentum described above for subsp. *revolutus*. Specimens from Goose Island and Lucky Bay are of the same taxon as the type of *Styphelia obovata* collected at Esperance Bay, and are therefore representative of the typical subspecies of *L. obovatus*.

Leucopogon rubricaulis R.Br., *Prodr. Fl. Nov. Holl.* 542 (1810). *Styphelia rubricaulis* (R.Br.) Spreng., *Syst. Veg.* 1: 656 (1824). *Type*: King George Sound [Western Australia], December 1801, *R. Brown s.n.* (*lecto*, here designated: BM 000907505!).

Leucopogon villosus R.Br., *Prodr. Fl. Nov. Holl.* 542 (1810). *Styphelia villosa* (R.Br.) Spreng., *Syst. Veg.* 1: 657 (1824). *Type*: King George Sound [Western Australia], December 1801, *R. Brown s.n.* (*lecto*, here designated: BM 000907504!).

Leucopogon angustatus Benth., in S.F.L.Endlicher, E.Fenzl, G.Bentham, & H.W.Schott, *Enum. Pl.*: 77 (1837). *Type*: King George Sound [Western Australia, 1–11 January 1834], *C.A.A.F. von Hügel s.n.* (*iso*: MEL 78331!).

Leucopogon angustatus Benth. var. *hirsutus* Sond., in J.G.C.Lehmann, *Pl. Preiss.* 1: 311 (1845). *Type*: In regionibus interioribus Australiae meridionali-occidentalis, *L. Preiss* 394 (*syn*: LD 1000221, image seen).

Leucopogon sp. Denmark (J.M. Powell 1167), in G.Paczkowska & A.R.Chapman, *West. Austral. Fl.: Descr. Cat.*: 240 (2000); in J.Wheeler, N.Marchant, & M.Lewington, *Fl. South West* 2: 603 (2002).

Erect, open *shrubs* to 1.5 m high and 1.5 m wide, single-stemmed at ground level with a fire-sensitive rootstock. Young *branchlets* usually glabrous or with a sparse to moderately dense (rarely dense), ± monomorphic indumentum of patent, straight or decurved hairs, 0.02–0.40 mm long. *Leaves* spirally arranged, variously orientated, from steeply antrorse to steeply retrorse, narrowly ovate to narrowly elliptic (where leaf margins are slightly recurved only) or oblong to linear (where strongly recurved or revolute), 4.5–18.0 mm long, 0.7–2.8 mm wide; apex acute, subacute or obtuse with a ± recurved callus point; base attenuate or cuneate; petiole broad, rather poorly defined, cream-coloured to pale brown, to *c.* 0.5 mm long, usually glabrous on abaxial surface and hairy on adaxial surface and margins, occasionally hairy throughout; lamina 0.15–0.25 mm thick, curvature variable, adaxial surface convex with the margins varying from slightly recurved with the abaxial surface visible throughout to revolute and the abaxial surface completely concealed, longitudinal axis usually ± straight, sometimes distinctly recurved; surfaces discolorous; adaxial surface shiny, usually glabrous to moderately hairy (rarely densely so), the venation usually indistinct but sometimes 3–5 sunken veins evident; abaxial surface paler, usually glabrous, but occasionally sparsely hairy, with 5–7 pale, flat or slightly sunken primary veins, the midrib often raised and rather thicker towards the apex; margins glabrous or irregularly ciliolate with coarse hairs to *c.* 0.3 mm long. *Inflorescences* erect, terminal and upper-axillary, often aggregated into dense conflorescences; axis 4–10 mm long with 4–13 flowers, terminating in a bud-like rudiment or an attenuate point; axis indumentum of moderately dense or dense patent hairs, 0.02–0.08 mm long; flowers erect and sessile. *Fertile bracts* ovate, 1.4–2.0 mm long, 0.9–1.3 mm wide, acute to obtuse. *Bracteoles* ovate, 1.4–2.4 mm long, 0.8–1.2 mm wide, obtuse, subacute or acute, sharply keeled; abaxial surface glabrous or with a sparse to moderately dense indumentum of short hairs, often with a few longer hairs about the keel, becoming scarious towards the margins; adaxial surface shortly hairy in the upper half or throughout; margins ciliolate. *Sepals* ovate or narrowly ovate, 2.0–2.8 mm long, 1.0–1.4 mm wide, obtuse or occasionally subacute; abaxial surface glabrous or with a variable, very short indumentum, the central portion pale greyish green, usually tinged reddish purple towards the apex and in a submarginal band, becoming scarious towards the margins, the venation usually obscure, although sometimes the midrib and the two nearest lateral veins ± conspicuous towards the apex; adaxial surface shortly hairy towards the apex; margins ciliate with hairs to 0.2 mm long. *Corolla tube* white, campanulate, shorter than the sepals, 1.1–1.7 mm long, 1.0–1.4 mm wide, glabrous externally and internally. *Corolla lobes* white or pink, much longer than the tube (ratio = 1.6–2.4:1), widely spreading from the base and recurved, 2.3–3.3 mm long, 0.5–0.9 mm wide at base, glabrous externally, densely bearded internally; indumentum white, 0.8–1.2 mm long near apex; glabrous tip 0.15–0.25 mm long. *Anthers* partially exserted from the tube (by 3/4–7/8 of their length), 1.3–2.0 mm long, recurved often strongly towards the apex; sterile tips white, conspicuous, 0.3–0.7 mm long. *Filaments* terete, 0.5–0.8 mm long, attached 1/2–2/3 above anther base, adnate to tube just below sinus. *Ovary* broadly obovoid or ± globose, 0.4–0.6 mm long, 0.4–0.6 mm wide, usually with short hairs in the upper half, occasionally glabrous, 4–5-locular. *Style* 0.5–0.8 mm long, well-differentiated from ovary apex, included within the corolla tube; *stigma* not or scarcely expanded; *nectary* annular 0.20–0.35 mm long, entire or very shallowly lobed, glabrous. *Fruit* oblongoid to narrowly ellipsoid, 3.0–3.9 mm long, 1.3–1.8 mm wide, much longer than the calyx, truncate with a broad, obscurely lobed rim, the surface between the rim and the style base descending steeply, usually shortly hairy about the apex, the hairs sometimes only on the descending surface and therefore difficult to see, occasionally glabrous, the surface grooved longitudinally, but otherwise smooth; style persistent. (Figure 4A)

Selected specimens examined. WESTERN AUSTRALIA: 1.3 km N along Nutcracker Rd from junction of Ficifolia Rd, NW of Peaceful Bay, 22 Oct. 2007, *R. Davis s.n.* (NSW, PERTH); Denmark Shire; Denbarker State Forest, 'the sand track', 3.1 km W from Denmark–Mount Barker Rd towards Stan Rd, 3 Sep. 1994, *B.G. Hammersley* 1125 (CANB, PERTH); access track to Granite Hill Nature Reserve, 1.4 km E of Moorialup Rd at junction of minor track, E of Porongurup, 16 Nov. 2003, *M. Hislop* 3089 (NSW, PERTH); Mount Barker–Denmark Rd, 2.3 km S of Spencer Rd, 1 Sep. 2005, *M. Hislop* 3502 (CANB, PERTH); Survey Downs Rd, *c.* 1 km N of Mt Barker–Porongurup Rd, locality of Porongurup, 3 Sep. 2005, *M. Hislop* 3510 (CANB, PERTH); Gull Rock Rd, 4 km N of Gull Rock, E of Albany, 15 Aug. 1986, *G.J. Keighery* 8316 (PERTH); Millbrook Nature Reserve, 25 km NNW of Albany, 8 Sep. 1987, *G.J. Keighery & J.J. Alford* 1644 (PERTH); Woolbale Hills, D'Entrecasteaux National Park, 6 Oct. 1997, *E.D. Middleton* EDM 63 (PERTH); 750 m N of the coast in Nuyts Wilderness, 2 km E of Poison Hill, 6 Oct. 1997, *E.D. Middleton* EDM 73 (PERTH); on edge of Cephalotus swamp, C. Milton's property, 3 km S of Mount Barker, 28 Mar. 1975, *K.F. Kenneally* 4580 (PERTH); near the Knoll and Nornalup Inlet, Walpole-Nornalup National Park, 14 Aug. 1979, *J.M. Powell* 1170 (CANB, CBG, K, L, NSW, PERTH); 8 km SW of Denbarker Rd turnoff on Denmark–Mt Barker Rd, 18 Aug. 1979, *J.M. Powell* 1206 (CANB, K, L, MEL, NSW, PERTH); Hunwick South Rd junction with Lower Denmark–Albany Rd, 21 Aug. 1979, *J.M. Powell* 1264 (CANB, HO, K, L, NSW, PERTH); Granite rocks above Cheyne Beach, 22 Aug. 1979, *J.M. Powell* 1291 (AK, CANB, K, L, NSW, PERTH); Boat Harbour Rd, *c.* 4 km SW of South Coast Highway [W of Denmark], 25 July 1982, *J.M. Powell* 1960 (AK, BISH, CANB, HO, K, L, MEL, NSW, PERTH, RSA); 1.2 km N from coastal end of Ledge Point [Beach] Rd [E of Albany], 29 Aug. 1986, *J.M. Powell* 2684 (NSW, PERTH); Lower Kalgan River, 15 Aug. 1951, *R.D. Royce* 3726 (PERTH); Narrikup, 29 July 1953, *R.D. Royce* 4240 (PERTH); by King River, *c.* 1 km SW of King River settlement (N of Albany), 23 Sep. 1982, *A. Strid* 20436 (PERTH); Plot 5454 Boulder Hill [near Two Peoples Bay], 6 Oct. 1992, *G. Wardell-Johnson & A.R. Annels* ARA 2527 (PERTH).

Distribution and habitat. Leucopogon rubricaulis is restricted to near south coast localities between Broke Inlet [W of Walpole] and Cheyne Beach [*c.* 60 km E of Albany] and as far north as the Mount Barker area (Figure 5). This places it within the Warren and Jarrah Forest IBRA bioregions (Department of the Environment, Water, Heritage and the Arts 2008). It grows in a variety of vegetation types in both dry and winter-wet habitats in either deep sand or shallow sandy soils over granite or occasionally laterite.

Conservation status. Although a regional endemic, this is a locally common species which is known to occur in a number of National Parks and Nature Reserves. No conservation coding is recommended here.

Affinities. Despite their superficially similar appearance, the morphological differences between *Leucopogon rubricaulis* and *L. obovatus* are significant. The fruiting character of the former clearly places it in Group C *sensu* Hislop & Chapman (2007) and is qualitatively different from that of *L. obovatus* which was assigned to Group A. In common with the other members of Group C, the drupes of *L. rubricaulis* are oblongoid or narrowly ellipsoid, longitudinally grooved with a truncate apex and

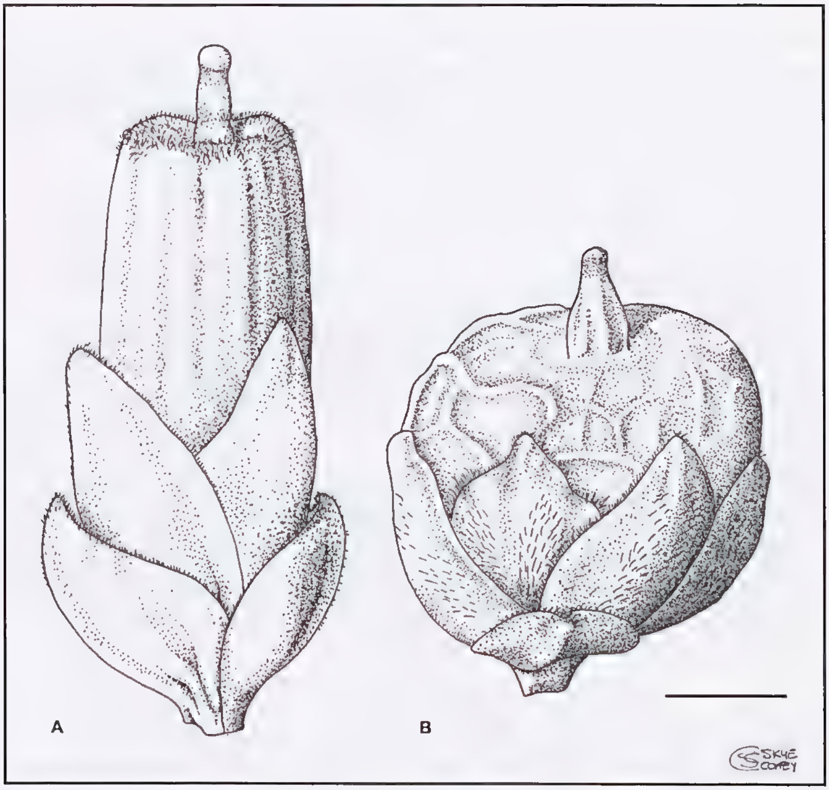

Figure 4. *Leucopogon rubricaulis*. A – fruit. *Leucopogon obovatus* subsp. *obovatus*. B – fruit. Scale bar = 1 mm. Drawn by Skye Coffey from *M. Hislop* 3089 (A), *W. Greuter* 22878 (B).

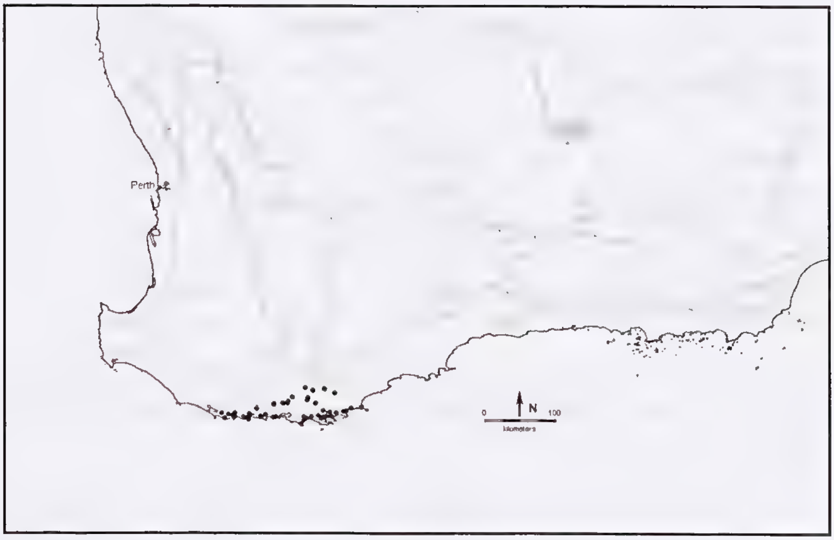

Figure 5. Distribution of *Leucopogon rubricaulis* in south-west Western Australia.

no mesocarp evident (Figure 4A). In contrast those of *L. obovatus* are globose or depressed-globose, with smoothly rounded shoulders and an obvious mesocarp manifesting as a prominent reticulum on dried specimens (Figure 4B). The two species can also be separated by a different foliar indumentum. Whereas in *L. obovatus* the upper leaf surface has characteristically short, antrorse, tubercle-based hairs (sometimes abraded on older leaves, the surface remaining verrucose), in *L. rubricaulis* it is always smooth and often glabrous. If an indumentum is present, although it may be quite variable, it is never of the kind described above for *L. obovatus*.

The combination of recurved to revolute leaf margins and a usually hairy ovary makes *L. rubricaulis* relatively easy to distinguish from the other members of Group C that occur on the south coast. It could possibly be mistaken for *L. assimilis* R.Br., in that the two species share relatively long, narrow leaves and co-occur in near-coastal habitats around Albany. There is however an obvious difference in the leaf curvature between the two, the leaves of *L. assimilis* being adaxially concave and with the abaxial surface prominently ribbed.

Notes. That *Leucopogon rubricaulis* should have been placed in synonymy under *L. obovatus* (as *L. revolutus*) by Bentham (1868) seems particularly surprising given that fruit of the two species was apparently available to him. The type material of *L. rubricaulis* collected by Brown is fruiting and shows the characteristically elongate and truncate drupe of that species. In Bentham's (1868) description of *L. revolutus* however, the fruit shape is given as 'nearly globular' which although apt for *L. revolutus* is difficult to reconcile with the type of *L. rubricaulis*.

In his description of *L. villosus*, Brown (1810) made mention of a close similarity with *L. rubricaulis*, the two apparently differing only in regard to indumentum. Although the long hairs seen on the vegetative parts of the type of the former are unusual (there are no specimens at PERTH that are closely comparable) there are good reasons to believe that the two should be regarded as conspecific. While a majority of collections of *L. rubricaulis*, including the type, have branchlets and leaves that are either glabrous or very shortly hairy there are a number of specimens with a moderately dense indumentum on these parts. Particularly noteworthy in this regard are three collections made by J.M. Powell at the same site in the Torbay area, west of Albany. Two of these (JMP 1264 and 1265) have glabrous leaves and minutely hairy branchlets, while the third (JMP 1266) has a conspicuous indumentum of quite long hairs covering its vegetative parts. Although perhaps not as extreme as the contrast between the types of *L. rubricaulis* and *L. villosus*, this kind of dimorphism also occurs elsewhere in Group C, notably in *L. pulchellus* Sond. and *L. polymorphus* Sond. Aside from the indumentum, there are no other foliar characters to separate *L. villosus*. In addition, and crucially, although the lectotype of *L. villosus* has very little fertile material present, the remains of an old flower showed the ovary apex to be minutely hairy. This relatively uncommon feature is present in all but a very few collections of *L. rubricaulis*. Examination of a scanned image of type material of *L. angustatus* var. *hirsutus* Sond., suggests that this should also be regarded as a (moderately) hairy variant of *L. rubricaulis*.

Although no type specimens of *L. angustatus* could be located at W, K, or BM, the MEL isotype is typical of *L. rubricaulis* in all respects. Another Hügel collection (MEL 78316) from King George Sound has the characteristic indumentum of *L. obovatus* subsp. *revolutus*. This specimen, from Sonder's herbarium, is annotated in his writing '*Leucopogon villosus* Benth! in Hügel Enumeratio'. This suggests that it is part of the collection that Bentham assigned to *L. villosus* (i.e. no. 266, in Bentham 1837) and provides further indication of Bentham's changing concepts within this group of species.

Lectotypification of *Leucopogon capitellatus* var. *sparsiflorus*

Leucopogon capitellatus DC., *Prodr.* 7(2): 747 (1839). *Type*: 'in Novâ-Hollandiâ ad Swan-river', [Western Australia 1835–1838], *J. Drummond s.n.* (*holo*: G-DC, image seen; *iso*: K 000348344 scanned image seen).

Leucopogon capitellatus DC. var. *sparsiflorus* Sond. [published as β *sparsiflorus*] in J.G.C.Lehmann, *Pl. Preiss.* 1: 312 (1845). *Type*: In glareosis inter frutices montis prope fontem St. Ronan's well [W of York, Western Australia], 25 April 1840, *L. Preiss* 427 (*lecto*, here designated: MEL 2102508!).

Notes. Although common and with a wide distribution throughout the wetter parts of the south-west of Western Australia (from Perth to the Albany area), *Leucopogon capitellatus* is a fairly uniform species with relatively minor variation in leaf size and curvature, indumentum and sepal shape. Because it was collected in April the type of *L. capitellatus* var. *sparsiflorus* has only a few dead flowers present. Just the same, the material is good enough to allow an unequivocal determination that it is typical for *L. capitellatus*. It seems probable that Sonder was misled by the poor quality of the collection, and the limited number of specimens of *L. capitellatus* that were available to him. The inflorescence characters that he used to separate his new variety (i.e. a fewer-flowered, axillary-only inflorescence which was neither spike-like nor capitate) certainly do not hold up in the light of the variation that is observable across the species.

The specimen lectotypified here is from Sonder's personal collection.

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References

Bentham, G. (1837). *In*: Endlicher, S.F.L., Fenzl, E., Bentham, G. & Schott, H.W. *Enumeratio plantarum quas in Novae Hollandiae ora austro-occidentali ad fluvium Cygnorum et in Sinu Regis Georgii collegit Carolus liber Baro de Hügel.* (Beck: Vienna.)

Bentham, G. (1868). *Flora Australiensis* .Vol. 4. (Reeve: London.)

Blackall, W.E. & Grieve, B.J. (1981). *How to know Western Australian wildflowers. Part III B.* (University of Western Australia Press: Nedlands, WA.)

Brown, R. (1810). *Prodromus florae Novae Hollandiae.* Vol. 1. (Johnson: London.)

Centre for Australian National Biodiversity Research, Australian Government (1991–). *Australian Plant Name Index, IBIS database.* http://www.cpbr.gov.au/cgi-bin/apni [accessed April 2011]

Department of the Environment, Water, Heritage and the Arts (2008). *Interim Biogeographic Regionalisation for Australia (IBRA)*, Version 6.1. http://www.environment.gov.au/parks/nrs/science/bioregion-framework/ibra/index.html [accessed April 2011]

Hislop, M. & Chapman, A.R. (2007). Three new and geographically restricted species of *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from south-west Western Australia. *Nuytsia* 17: 165–184.

Hislop, M. (2009a). The taxonomy of *Leucopogon bossiaea* and allied species (Ericaceae: Styphelioideae: Styphelieae) from the central south coast of Western Australia. *Nuytsia* 19: 17–35.

Hislop, M. (2009b). New taxa in the *Leucopogon gracilis* group (Ericaceae: Styphelioideae: Styphelieae). *Nuytsia* 19: 211–228.

Labillardière, J.J. H. de (1804–1806). *Novae Hollandiae plantarum-specimen.* (Huzard: Paris.)

Sonder, O.W. (1845). Epacrideae. *In*: Lehmann, J.G.C. (ed.) *Plantae Preissianae* .Vol. 1. (Meissneri: Hamburg.)

Amanita ochroterrea and *Amanita brunneiphylla* (Basidiomycota), one species or two?

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Abstract

Davison, E.M. *Amanita ochroterrea* and *Amanita brunneiphylla* (Basidiomycota), one species or two? *Nuytsia* 21(4): 177–184 (2011). *Amanita ochroterrea* Gentilli ex Bas and *A. brunneiphylla* O.K.Miller are robust, macroscopically similar mushrooms described from the south-west of Western Australia. According to the protologue of *A. brunneiphylla,* the main difference between them is the presence (in *A. ochroterrea*) or absence (in *A. brunneiphylla*) of clamp connections. However, in the current study abundant clamp connections have been observed in the holotype and paratypes of *A. brunneiphylla.* As other microscopic characters are indistinguishable, *A. brunneiphylla* is synonymised with *A. ochroterrea,* and an expanded description presented.

Introduction

Amanita species are large, conspicuous mushrooms with a worldwide distribution. They are readily recognized to the generic level in the field, but the majority are difficult to separate into species solely on their appearance. Microscopic characters are usually needed before collections can be confidently identified. The most commonly used microscopic characters are spore size and shape, their response to Melzer's iodine, the presence of clamp connections in the basidiome especially at the base of basidia, the structure of the subhymenium and underlying lamella trama, the pileipellis, and the structure of the universal veil on the pileus. All of these characters are used to separate species and construct diagnostic keys (Bas 1969; Reid 1979; Tulloss 1994; Wood 1997).

In 1953 Gentilli described several collections of *Amanita* spp. from Kings Park, Perth, Western Australia which included two large specimens with an earthy buff cap, buff lamellae and pale buff spore print that he called *A. preissii* (Fr.) Sacc. forma *ochroterrea* Gentilli (Gentilli 1953). This forma was not validly published since it was not accompanied by a Latin description or diagnosis. Gentilli sent these specimens to Bas who considered them to be so distinctive that he described them as a new species, *A. ochroterrea* Gentilli ex Bas (Bas 1969; MB308574).

Following a visit to the south-west of Western Australia in 1989, Miller described *A. brunneiphylla* O.K.Miller (MB358165), a robust species with a dull white cap, light brown lamellae and a pale yellow spore print. He recognised that this was similar to *A. ochroterrea*, but separated the two species on the presence (in *A. ochroterrea*) or absence (in *A. brunneiphylla*) of clamp connections, together with small differences in spore size and colour of the lamellae (Miller 1991).

This paper reports a re-examination of the holotype and paratypes of *A. brunneiphylla* held at the Western Australian Herbarium (PERTH). These are compared with the published description of *A. ochroterrea*. Additional collections named as *A. ochroterrea* in PERTH, and macroscopically similar specimens held in private collections in Western Australia have also been examined. As a result, *A. brunneiphylla* is synonymised with *A. ochroterrea* and an expanded description is provided.

Materials and methods

Methodology follows that of Tulloss (2000, 2008). Colours are from the Royal Botanic Garden, Edinburgh (1969) and colour codes in the form of 'p3A2' are from Kornerup and Wanscher (1978). Dried material was rehydrated in 10 % NH_4OH or 3 % KOH and stained with 1 % Congo Red. Biometric variables for spores follow Tulloss and Lindgren (2005), i.e. '**L** = the average spore length computed for one specimen examined and the range of such averages, **L′** = the average spore length computed for all spores measured, **W** = the average spore width computed for one specimen examined and the range of such averages, **W′** = the average spore length computed for all spores measured, Q = the ratio of length/breadth for a single spores and the observed range of the ratio of length/breadth for all spores measured, **Q** = the average value of Q computed for one specimen examined and the range of such averages, **Q′** = average value of Q computed for all spores measured'.

Comparison of *Amanita ochroterrea* and *A. brunneiphylla*

The macroscopic descriptions of *A. ochroterrea* and *A. brunneiphylla* are similar; however, the protologue of *A. brunneiphylla* states that the flesh is 'firm, dull white tinted grey at the base' (Miller 1991). An image (E567) of a paratype (PERTH 007565259, *O.K. Miller* OKM 23747, as reproduced in Figure 1A, shows that the flesh is tinted brown, however, this may have resulted from drying. Neither Gentilli (1953) nor Bas (1969) comment on the colour of the context.

The microscopic characters of the holotype and paratypes of *A. brunneiphylla* do not differ from the type description of *A. ochroterrea* (Table 1). Basidiospore dimensions, amyloid reaction, size of basidia, and shape of lamella edge cells in all mature collections are similar to those of the type description of *A. ochroterrea*. Clamp connections are present and abundant in all of these collections; thus the original description of *A. brunneiphylla* is neither supported by the holotype nor the paratypes.

These observations did not detect any significant differences between these taxa. As a result, *A. brunneiphylla* is synonymised with *A. ochroterrea*. An expanded description of *A. ochroterrea* is provided.

Expanded description of *Amanita ochroterrea*

Amanita ochroterrea Gentilli ex Bas, *Persoonia* 5: 505–506, figures 278–281 (1969). *Amanita preissii* (Fr.) Sacc. f. *ochroterrea* Gentilli, *W. Austral. Naturalist* 4: 30, figure 3 (1953), (*nom. inval.*, Art. 36.1). *Type*: Perth, Kings Park, Western Australia, June 1953, *J. Gentilli s.n.* (*holo*: L). (MB308574).

Amanita brunneiphylla O.K.Miller, *Canad. J. of Bot.* 69: 2694 (1991). *Type*: Murdoch University campus, Western Australia, 7 May 1989, *O.K. & H.H. Miller, E.M. & P.J.N. Davison* OKM 23621 (*holo:* PERTH 07587473, image E 511). (MB358165).

Basidiome small to very large (Figures 1A, B). *Pileus* 35–170 mm diam, up to 15 mm thick, hemispheric when young, becoming more or less plane with a depressed centre with age, cream, pale buff to pale olivaceous buff (p1A2–p2B4–p4B3), margin of the pileus appendiculate, non-sulcate, no surface staining or bruising reaction. *Universal veil on pileus* (Figure 1C) adnate, forming a soft thin crust over the whole pileus, sometimes with small floccose warts in the centre, sometimes with thick felty angular flattened warts in the centre, cream, pale grey olivaceous, pale vinaceous buff, pale buff to pale olivaceous buff (p1A2–p3B5–p4B3). *Lamellae* close, free to narrowly adnate, 5–15 mm broad, ventricose, buff, olivaceous buff, hazel (p1B2–p5C4–6), drying buff to snuff brown (p5C4–F7), often with two tiers of plentiful lamellulae, the shorter truncate, the longer attenuate, lamella margin lighter in colour and slightly fimbriate. *Stipe* length (bottom of pileus context to top of bulb) 60–115 mm; width at mid-stipe 14–37 mm, more or less equal, solid, pale olivaceous buff, pale buff (p2B4–p4B3), furfuraceous or covered in mealy scales below the partial veil. *Partial veil* superior, descendent, soft, fugacious, initially greenish cream darkening to pale olivaceous buff (p1A2–B2). *Bulb* 55–72 × 28–44 mm, initially ovoid, narrowing with age, olivaceous buff, encrusted with sand. *Remains of universal veil* at the base of the stipe soft ridges and scales, in some specimens forming girdles; loose patches often remaining in the soil. *Flesh* cream, straw, to pale olivaceous buff (p1A2–p2B5) in both pileus and stipe, sometimes darkening on exposure to air. *Smell* mild and earthy when young, stronger when older. *Spore deposit* cream (p3A2–3) to buff.

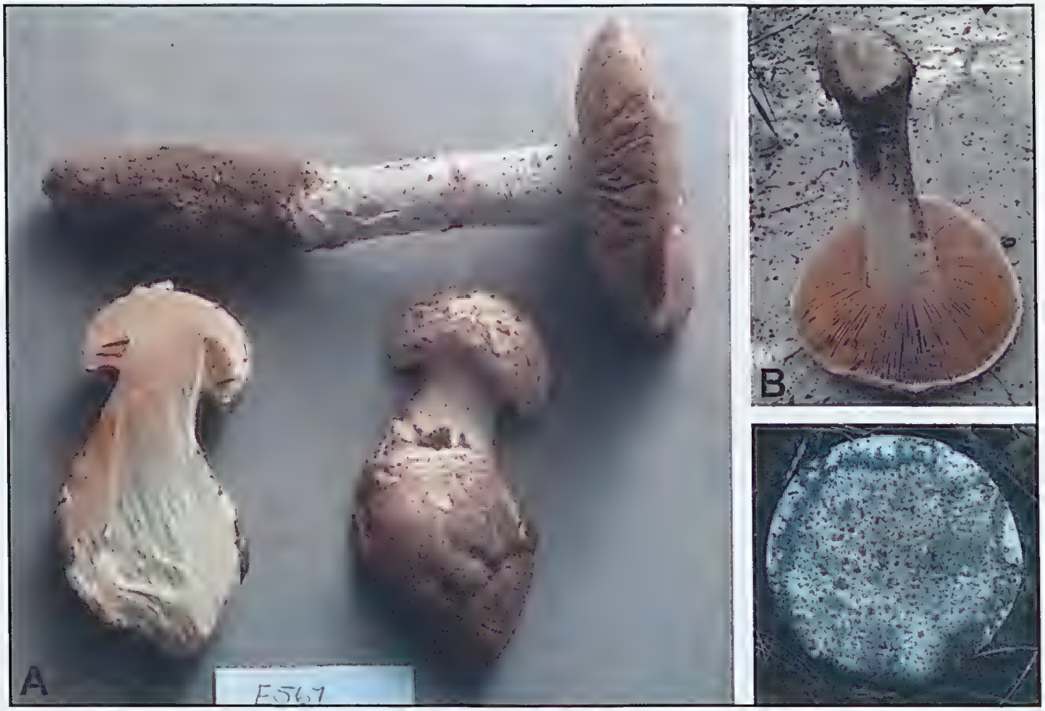

Figure 1. *Amanita ochroterrea*. A – showing the brownish colour of freshly exposed flesh (paratype of PERTH 07565259, *O.K. Miller* OKM 23747); B – *Amanita ochroterrea* (PERTH 08334897, B-S 168); C – surface of pileus (PERTH 08059632, *E.M. & P.J.N. Davison* EMD 6-2008). Photographs by N.L. Bougher (A), L.I. Little (B) and E.M. Davison (C)

Table 1. Comparison of the type descriptions of *Amanita ochroterrea* and *A. brunneiphylla* with observations from holotype and paratype collections of *A. brunneiphylla.*

	A. ochroterrea type description (Bas 1969)	*A. brunneiphylla* type description (Miller 1991)	*A. brunneiphylla* PERTH 07587473 holotype	*A. brunneiphylla* PERTH 07587562 paratype	*A. brunneiphylla* PERTH 07564465 paratype	*A. brunneiphylla* PERTH 07565259 paratype
Basidiospores L × W (µm)	(10–)11–13 (–13.5) × 5–6.5 (20/1)	(8–)9–10.8 × 4.1–5	(8–)9–12 × 4.5–5 (20/1) from lamella	no spores, basidia immature	no spores, basidia immature	(8.5–)9.5–11(–11.5) × 4.5–6 (15/1) from lamella
Q	1.9–2.4, mean 2.1	1.8–2.3, mean 2.1	2.0–2.7, mean 2.2			1.7–2.3, mean 2.0
Amyloidy	amyloid	amyloid	amyloid			amyloid
Basidia L × W (µm)	50–55 × 11–12	34–38 × 7–10	38–45 × 9–10	basidia immature	basidia immature	30–50 × 9–11
Lamella edge cells (size in µm)	globose to clavate, 15–35 × 15–20	pyriform to clavate, 18–26 × 9–15	pyriform to clavate, up to 25 × 12	clavate to spherical, 15–40 × 10–15	clavate to pyriform, 20-28 × 14-20	globose, clavate to cylindric, <20 wide
Subhymenium	probably ramose	isodiametric cells	inflated ramose	ramose	ramose	ramose
Clamp connections	present at base of basidia and in pileipellis	none seen in any tissue	present and abundant in all tissues	Present and abundant in all tissues	present and abundant in all tissues	Present and abundant in all tissues

Basidiospores (Figure 2A) [161/9/8] (8–) 9.5–13(–15) × (4–)4.5–6 (–6.5) µm, **L** = 10.1–11.7 µm; **L′** = 11.0 µm; **W** = 4.7–5.6 µm; **W′** = 5.2 µm; Q (1.67–) 1.82–2.44(–3.00), **Q** = 2.00–2.23; **Q′** 2.13) hyaline, colourless, thin-walled, smooth, amyloid, elongate to cylindrical, infrequently bacilliform, adaxially flattened, with apiculus sublateral, truncate, about 1 × 1 µm, with granular contents. *Pileipellis* difficult to delimit, merging into both universal veil and pileus context, not or slightly gelatinized at the centre, gelatinization of the hyphal walls in some specimens near the pileus margin; hyphae 2–10 µm wide, thin walled, hyaline, orientation mainly radial with some interweaving. *Pileus context* tissue yellow in NH_4OH, hyphae 6–30 µm wide, thin walled, hyaline, dominant, mainly with radial orientation; inflated cells up to 60 × 250 µm, thin walled, colourless. *Lamella trama* bilateral; width of central stratum 40–60 µm, hyphae 5–20 µm wide, no inflated cells seen; subhymenial base 25–60 µm wide, hyphae 4–20 µm wide, dominant orientation is initially about 30° from the vertical with the hyhae bending round in a smooth curve to the subhymenium, inflated cells up to 20 × 70 µm, infrequent; subhymenium (Figure 2B) 20–40 µm wide, ramose to inflated ramose, thin-walled; lamella margin cells (Figure 2C) globose, pyriform to clavate up to 10–15 × 25–40 µm. *Basidia* [132/7/7] (30–)35–60(–65) × (7.5–)9–11(–12.5) µm, thin-walled, yellow contents in NH_4OH, about 90 % four-spored about 10 % two-spored, sterigmata up to 5 µm long by 2 µm wide at the base; basal clamps present. *Universal veil on the pileus* (Figure 2E) comprising abundant mainly ellipsoidal to spherical, rarely pyriform to clavate, venticose to fusiform cells up to 70 × 150 µm, but most smaller, inflated cells terminal or in short chains; filamentous hyphae 5–10 µm wide, frequently branched, irregularly disposed, hyphae more abundant in the proximal part of the universal veil, while the inflated cells are more abundant in the distal part of the universal veil; some gelatinization of the walls of both filamentous and inflated hyphae evident in older specimens. *Universal veil on the stipe base* disordered tissue of terminal spherical and clavate cells up to 30 × 150 µm and filamentous hyphae 3–12 µm wide. *Stipe context* acrophysalidic, with acrophysalides up to 30 × 300 µm dominant, filamentous hyphae 3–13 µm wide with mainly axial orientation. *Partial veil* (Figure 2D) of dominant spherical to clavate or pyriform inflated cells 15–20 × 50 µm, but occasionally up to 30 × 300 µm, and infrequent, mainly radial, filamentous hyphae 2–8 µm wide. *Vascular hyphae* present but infrequent in all tissues, 2–15 µm wide, occasionally branched, thin walled, with yellow glassy contents in NH_4OH, frequently serpentine, no knots or concentrations of vascular hyphae noted in any tissue. *Clamp connections* present and frequent in all tissues.

Collections examined. WESTERN AUSTRALIA: Murdoch University campus, 25 Apr. 1990, *E.M. & P.J.N. Davison* EMD 12-1990 (PERTH 08059640); Melville, 12 May 2008, *E.M. & P.J.N Davison* EMD 6-2008 (PERTH 08059632); near Southern Cross, 23 June 1974, *B. Dell & K. Elson s.n.* (PERTH 00768804, UWA 1862); Swan View, 20 May 2005, *K. Griffiths* B-S 168 (PERTH 08334897); Murdoch University campus, 7 May 1989, *O.K. & H.H. Miller, E.M. & P.J.N. Davison*, OKM 23621 (PERTH 07587473, E 511 holotype of *A. brunneiphylla*); Kings Park, 21 May 1989, *O.K. & H.H. Miller* OKM 23660 (PERTH 07587562, E 529 paratype of *A. brunneiphylla*); Moore River, 23 May 1989, *O.K. & H.H. Miller* OKM 23720 (PERTH 07564465, E 560 paratype of *A. brunneiphylla*); Regans Ford, 30 May 1989, *O.K. & H.H. Miller* OKM 23747 (PERTH 07565259, E 567 paratype of *A. brunneiphylla*); Kings Park, 26 May 1982, *anon. s.n.* (PERTH 07607512, E 239).

Rejected collections. Corrigin shire, *J. Catchpole, I.C. Tommerup & N.L. Bougher s.n.*, 8 July 1999 (PERTH 07658508, E 6235); Grass Patch, *T.C. Daniell s.n.*, 18 Aug. 1984 (PERTH 00918326, UWA 2966) (green form); Gleneagle, *R.N. Hilton s.n.*, 18 June 1975 (PERTH 00771961, UWA 2001); Walpole Nornalup National Park, *K. Syme* 29:87, 24 May 1987 (PERTH 07575270, UWA 3510).

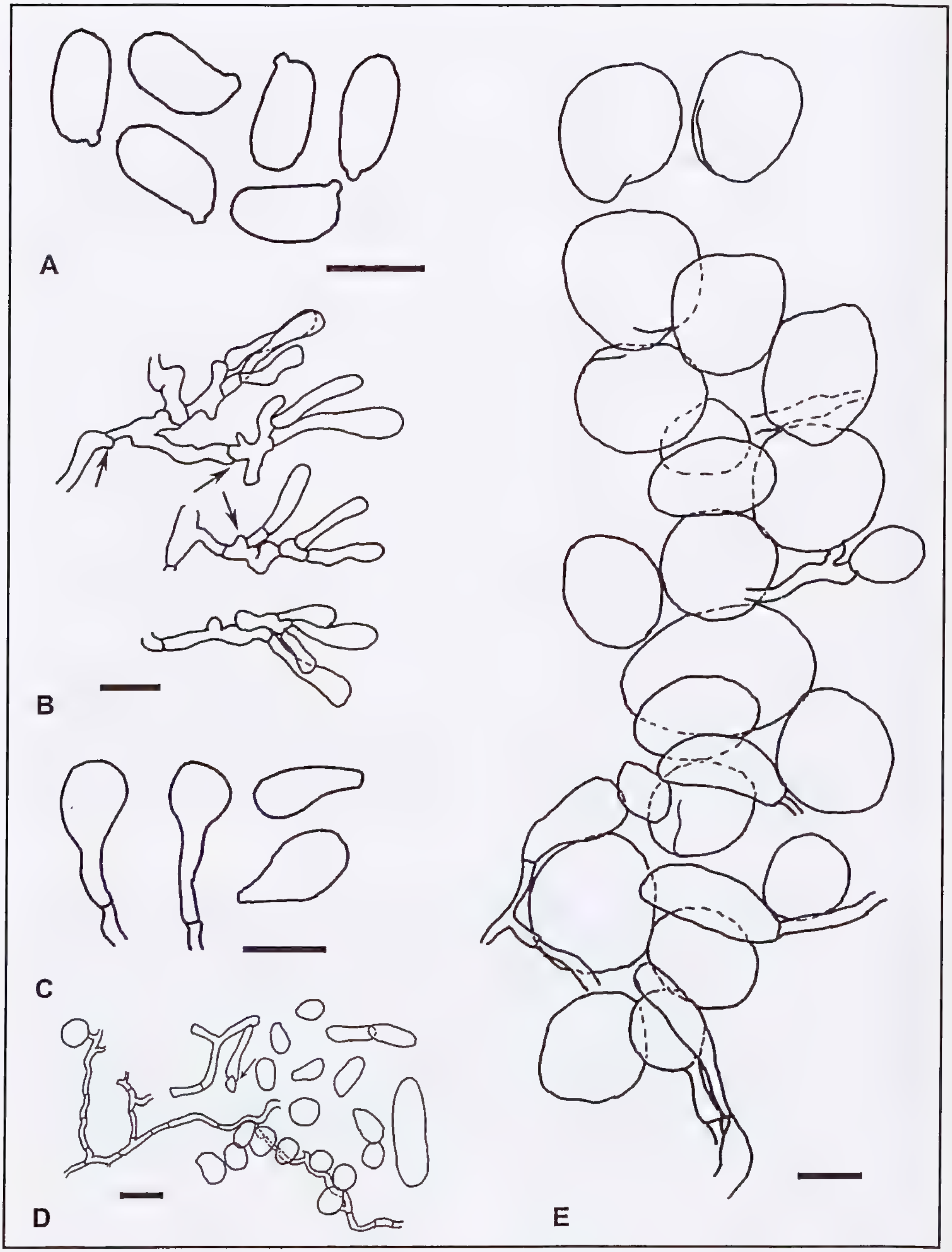

Figure 2. *Amanita ochroterrea*. A – spores from spore print; B – squash of young basidia and subhymenium, clamp connections indicated by arrows; C – lamella edge cells; D – cells from the partial veil, clamp connection indicated by an arrow; E – vertical section through the universal veil on the pileus, the proximal part is at the bottom. A, C, D, E (PERTH 08059632, *E.M. & P.J.N. Davison* EMD 6-2008); B (PERTH 07587562 *O.K. Miller* OKM 23660, paratype of *A. brunneiphylla*). Scale bars A = 10 µm, B–E = 20 µm.

These collections have been rejected for the following reasons: PERTH 07658508 has a saccate volva and probably resides in Section *Amidella*; PERTH 00771961 and PERTH 07575270 have been rejected because they have low **Q**: 1.64 and 1.72 respectively; PERTH 00918326 has a much wider central stratum and wider lamellae.

Distribution and habitat. Solitary or gregarious, in sandy soil in dry sclerophyll woodland and sand plain, often associated with *Eucalyptus marginata* Sm. and *Corymbia calophylla* (Lindl.) K.D.Hill & L.A.S.Johnson. *Amanita ochroterrea* is a distinctive species that is widely distributed in the south-west of Western Australia from the Moore River (31°00′ S, 115°30′ E) to Southern Cross (31°13′ S, 119°18′ E) although it does not appear to be common. It has not been recorded in South Australia (Grgurinovic 1997) or eastern Australia (Wood 1997).

Fruiting period. April to August.

Diagnostic features. Robust basidiomes with buff pileus, brown gills, yellowish spore print and clamp connections throughout.

Suggested common name. Brown-gilled amanita.

Notes. Bas (1969) placed *A. ochroterrea* in *Amanita* (subsection *Solitariae* Bas) Stirps *Grossa* in part because of the irregularly disposed remnants of the universal veil on the pileus. He commented, however, that these remnants were difficult to analyse. The collections examined here support Bas' placement of *A. ochroterrea* in Stirps *Grossa* because the basidia have clamp connections, **Q** is less than 2.2, the universal veil on the pileus forms a subfelted layer and is composed of irregularly disposed inflated cells intermixed with hyphae.

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The Western Australian Herbarium (PERTH) is thanked for the loan of collections of *A. ochroterrea* and *A. brunneiphylla*. H.H. Miller kindly provided additional information about the O.K. Miller collections from Western Australia. N.L. Bougher is thanked for an image of PERTH 007565259. K. Griffiths is thanked for the gift of collection B-S 168 and L.I. Little is thanked for an image of this collection. I thank R.E. Tulloss, N.L. Bougher and K.R. Thiele for constructive discussions and feedback on the manuscript.

References

Bas, C. (1969). Morphology and subdivision of *Amanita* and a monograph of its section *Lepidella*. *Persoonia* 5: 285–579.

Gentilli, J. (1953). Amanitas from King's Park, Perth. *The Western Australian Naturalist* 4: 25–34, 59–63.

Grgurinovic, C.A. (1997). *Larger fungi of South Australia.* (The Botanic Gardens of Adelaide and State Herbarium: Adelaide.)

Kornerup, A. & Wanscher, J.H. (1978). *Methuen handbook of colour.* (Methuen: London.)

Miller, O.K. (1991). New species of *Amanita* from Western Australia. *Canadian Journal of Botany* 69: 2692–2703.

Reid, D.A. (1979). A monograph of the Australian species of *Amanita* Pers. ex Hook. (Fungi). *Australian Journal of Botany Supplementary Series* No. 8: 1–97.

Royal Botanic Garden, Edinburgh. (1969). *Flora of British fungi: colour identification chart.*(Her Majesty's Stationery Office: Edinburgh.)

Tulloss, R.E. (1994). Type studies in *Amanita* Section *Vaginatae* I: some taxa described in this Century (studies 1–23) with notes on description of spores and refractive hyphae in *Amanita. Mycotaxon* 52: 305–396.

Tulloss, R.E. (2000). Note sulla metodologia per lo studio del genere Amanita (Agaricales). *Bollettino del Gruppo Micologico G. Bresadola Trento* 43(2): 41–58

Tulloss R.E. (2008). Notes on methodology for study of *Amanita* (Agaricales). *In*: Tulloss, R.E & Yang, Z.L. *Studies in the genus Amanita Pers.* (*Agaricales, Fungi*) http://www.amanitaceae.org/content/uploaded/pdf/methodsb.pdf. [accessed 12 May 2008]. [English original of Tulloss (2000)]

Tulloss, R.E. & Lindgren, J.E. (2005). *Amanita aprica* – a new toxic species from western North America. *Mycotaxon* 91: 193–205

Wood, A.E. (1997). Studies in the genus *Amanita* (Agaricales) in Australia. *Australian Systematic Botany* 10: 723–854.

Referees for Volume 21

The assistance of referees in providing expert review of papers submitted to *Nuytsia* is gratefully acknowledged. The referees consulted for Volume 21 include those listed below. Each paper was also refereed internally by *Nuytsia* Editorial Committee members.

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Amanita ochroterrea and *Amanita brunneiphylla* (Basidiomycota), one species or two?. E.M. Davison 177

Short Communications

Valid publication of *Ptilotus stirlingii* subsp. *australis* (Amaranthaceae). R.W. Davis and R. Butcher 31

Removal of the informal name *Epiblema grandiflorum* var. *cyaneum* ms from the Census of Western Australian Plants. K.R. Thiele 33

Re-evaluation of some infraspecific taxa in *Ptilotus* (Amaranthaceae). R.W. Davis 149

Validation of the name *Drosera monticola* (Droseraceae), a species from the south-west of Western Australia. A. Lowrie 152

Melaleuca marginata, a new name for *Melaleuca coronicarpa* (Myrtaceae). M. Hislop, B.J. Lepschi and L.A. Craven 153

Other contents

Corrections 155

Referees for Volume 21 185

CONTENTS

Papers

Five new species of *Calandrinia* from Western Australia with additional information on morphological observations. F.J. Obbens 1

Wurmbea fluviatilis (Colchicaceae), a new riverine species from the Gascoyne region of Western Australia. T.D. Macfarlane and A.L. Case 25

New south-western Australian members of the genus *Petrophile* (Proteaceae: Petrophileae), including a hybrid. B.L. Rye, M.Hislop, K.A. Shepherd and C. Hollister 35

Stackhousia stratfordii (Celastraceae: Stackhousioideae), a remarkable new species from a remote location near Norseman, south-west Western Australia. W.R. Barker and G.T.B. Cockerton 69

New, locally endemic taxa in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae) from the Perth and midwest regions of Western Australia. M. Hislop 75

Labichea rossii (Fabaceae: Caesalpinioideae), a new species from the Yilgarn Ranges, Western Australia. N. Gibson 91

A new and rare species of *Ptilotus* (Amaranthaceae) from a suburban wetland of the eastern Swan Coastal Plain, Western Australia. R.W. Davis and C. Tauss 97

An assessment of infraspecific taxa in *Ptilotus* (Amaranthaceae) from Western Australia. R.W. Davis 103

A revision of *Dielsiodoxa* (Ericaceae: Styphelioideae: Oligarrheneae). D.E. Albrecht and M. Hislop 107

Sida picklesiana (Malvaceae), a new species from the Murchison-Gascoyne region of Western Australia. A.S. Markey, S. Dillon, G.T.B. Cockerton and R.M. Barker 127

Two species of *Inocybe* (fungi) introduced into Western Australia. N.L. Bougher and P.B. Matheny 139

Eremophila koobabbiensis (Scrophulariaceae), a new, rare species from the wheatbelt of Western Australia. R.J. Chinnock and A.B. Doley. 157

A reinstatement and a new combination in *Leucopogon* (Ericaceae: Styphelioideae: Styphelieae). M. Hislop 163

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